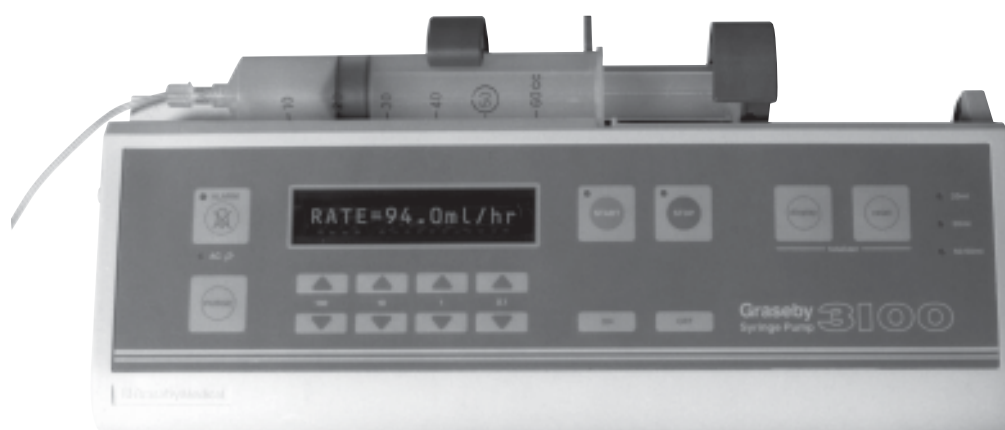


smiths

# Graseby 3100 Syringe Pump



## Technical Service Manual

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## Introduction

This Technical Service Manual for the 3100 together with the Instruction Manual for the pump, contains all the information that is needed in order to operate, maintain and repair the pump. The contents of this Technical Service Manual is primarily intended to be read and used by suitably qualified personnel. **Only qualified personnel should repair and maintain the pump.**

## AC input power connecting socket/cable

The AC input power socket that connects to the rear of the pump has three connections (live, neutral and earth) provided by a 3-way power cable. As the casing is doubly insulated, the AC input connector situated on the pump only utilises two connections (live and neutral), there is no third earth pin. This method of AC input enables similar AC input sockets (if required) to that supplied by Smiths Medical International to be used.

## Warnings and cautions

Warnings tell you about dangerous conditions that could lead to death or serious injury to the user or patient that can occur if you do not obey all of the instructions in this manual.

### WARNINGS

1. **WARNING:** To avoid over- or under- infusion, always verify that the brand and size of the loaded syringe are the same as the brand and size displayed on the screen before starting an infusion. Failure to do so may result in an inaccurate delivery of medication, resulting in patient injury or death.
2. **WARNING:** To avoid incorrect or inappropriate configuration of the pump, the Configuration menu must only be selected by qualified persons or authorised personnel. Incorrect pump configuration could lead to inappropriate infusion resulting in patient injury or death.
3. **WARNING:** This equipment is not suitable for use in the presence of flammable anaesthetics, oxygen-enriched or explosive atmospheres. The use of the device in such atmospheres may lead to explosion or fire.
4. **WARNING:** To avoid possible malfunction of the pump, do *not* expose the pump to X- rays, gamma rays or ionizing radiation, or to the RF interference or strong electric/magnetic fields emitted (for example) by diathermy equipment or mobile telephones. If the pump is used in the presence of, or in combination with Magnetic Resonance Imaging (MRI) machines it must be protected from the magnetic field emitted by such equipment. Malfunction of the pump can cause incorrect infusion or loss of infusion resulting in patient injury or death.
5. **WARNING:** Operation of the pump outside the temperature limits defined in the specification may result in erroneous operation. Ensure that the temperature is within the specified limits. Failure to do so may result in patient injury or user injury.
6. **WARNING:** In order to ensure that the intended infusion is performed, data must be entered correctly. Likewise before confirming any displayed data the user should ensure that it is correct. Failure to do so may result in compromised function of the product, patient injury or user injury.
7. **WARNING:** Failure to respond promptly to an alarm may result in patient injury or death.
8. **WARNING:** Failure to follow the *Service Manual's* maintenance schedule recommendations may result in compromised function of the product and lead to patient injury or death.
9. **WARNING:** It is essential that clinical staff remain within visual and audible range of the pump so that critical alarms can be seen or heard and responded to.
10. **WARNING:** The user should ensure that the performance offered by the pump is fit for the intended purpose. Failure to do so may result in compromised function of the product, patient injury or user injury.
11. **WARNING:** When the pump is carrying out an infusion, to ensure that electrical safety is maintained only items of equipment that conform to EN60950 are to be connected to the RS232 connector situated at the base of the pump, otherwise patient safety may be compromised.
12. **WARNING:** Correct management of battery charging is essential to ensure that the pump can operate on batteries for the time specified. Failure to do so may lead to impaired functioning of the pump, resulting in patient injury or death.
13. **WARNING:** Do *not* use a faulty pump. If the pump develops a fault then an alarm will sound; the display will indicate a **FAULT** condition and the pump will fail to infuse. Incorrect performance of the pump can cause complications resulting in patient injury or death.  
If the pump develops a fault then it must be referred to a suitably qualified engineer or returned to Smiths Medical in order to have the fault rectified.
14. **WARNING:** Failure to use the mains lead clamp means that the pump may be accidentally or erroneously disconnected from the mains. Although there is battery backup in case this happens, the battery may not be sufficiently charged. Consequently there is a risk of the pump not functioning, which could lead to patient injury or death.



15. **WARNING:** If an occlusion alarm occurs, immediately clamp the line to eliminate the possibility of a bolus being delivered to the patient. Then inspect the fluid pathway for kinks, clogged catheter, etc. in order to remove the occlusion prior to restarting the infusion. An unintentional bolus of medication can result in patient injury or death.
16. **WARNING:** Use only the syringes and administration sets listed in the *Specification* (Chapter 1). Failure to do so may result in an inaccurate delivery. Smiths Medical does not guarantee performance of the pump if syringes other than those listed are used. Incorrect function or performance of the pump can cause complications resulting in patient injury or death.
17. **WARNING:** The volume of fluid contained in the connecting tubing is a residual amount and will *not* be infused. Hence this extra volume of fluid must be allowed for when initially filling the syringe and purging the system. Under-delivery of medication can cause complications resulting in patient injury or death.
18. **WARNING:** To avoid patient embolism, ensure that the patient tubing is purged of all air bubbles before administering any medication. The pump provides a purge facility to assist with this process. The presence of air within the medication can result in complications leading to patient injury or death.
19. **WARNING:** To avoid syphoning of the syringe contents (free flow), ensure that the syringe is correctly loaded into the pump, that the syringe plunger is properly engaged by the pump's actuator and that the pump is placed not more than 80cm above the infusion site. Syphoning can result in over-infusion leading to patient injury or death.
20. **WARNING:** To avoid over-infusion, do not purge the infusion line when the administration set is connected to the patient. Over-infusion of medication can result in patient injury or death.
21. **WARNING:** To avoid the pump becoming detached from an IV pole always make sure that the pump is securely fixed to the pole. Always check the security and stability of the assembly with the pump mounted.
22. **WARNING:** Following a significant liquid spill onto the pump, it should be wiped dry and inspected by service personnel before being returned to service. Failure to do so may result in compromised functioning of the pump, leading to patient or user injury or death.
23. **WARNING:** When using a syringe smaller than 50/60 ml the occlusion pressure will increase as the diameter of the syringe decreases, i.e. the smaller the syringe the higher the pressure.
24. **WARNING:** The patient history is lost when the clock is reset.
25. **WARNING:** Only adequately qualified personnel should maintain and repair the pump.
26. **WARNING:** The pump must be disconnected from the AC power supply before the case is opened.
27. **WARNING:** The Configuration and Diagnostic mode must only be used by personnel who are adequately qualified and have previous training in the use of the pump.
28. **WARNING:** The safety and reliability of the pump may be compromised by the use of parts other than those specified in this Manual.
29. **WARNING:** When a new Syringe Size Sensor Flag has been fitted to the pump (see Appendix), then the pump must be tested using the new syringe size sensor gauges available from Smiths Medical (part number 0131-0202). Page 3 of the Appendix gives details of the Final Testing procedures.
30. **WARNING:** The pump must be set to display the brand and the size of syringe that is going to be used. Using a different brand or size of syringe to that being displayed could lead to the incorrect amount of drug being administered, that could result in injury or death.
31. **WARNING:** The internal pump batteries must be disposed of in accordance with the manufacturers instructions. Lead acid batteries must NOT be placed in the normal waste stream.

**CAUTIONS**

Cautions tell you about dangerous conditions that can occur and cause damage to the pump if you do not obey all of the instructions in this manual.

1. **CAUTION:** Refer all service, repair and calibrations only to qualified technical personnel. Unauthorised modifications to the pump must *not* be carried out.
2. **CAUTION:** When turning the pump on if screens similar to those illustrated are not displayed, do *not* use the pump. Send the pump to a suitably qualified engineer or return it to Smiths Medical in order to have the fault rectified.
3. **CAUTION:** Do not use cleaning and disinfecting agents other than the approved ones specified here.
4. **CAUTION:** The pump must *not* be immersed in any liquids or exposed to strong organic solvents. Wipe off spills immediately, and do not allow fluid or residues to remain on the pump. Additionally, the pump is not designed to be autoclaved, steam-sterilised, ETO-sterilised or subjected to temperatures in excess of 45° C (113° F). Failure to observe this caution may cause serious damage to the pump.
5. **CAUTION:** During the removal and replacement of a pump's components, strict observance to Electro Static Discharge (ESD) rules must be observed at all times, i.e. an earthing strap must be worn. Failure to apply ESD protection may result in serious damage to the product and possible malfunction. Ensure that any replacement printed circuit board or other ESD sensitive items are stored in an anti-static container.

**Abbreviations used**

The following list shows the abbreviations that have been used at various places throughout this Manual.

<b>Abbreviation</b>	<b>Full name</b>
A to D	Analogue to digital
AC	Alternating current
C	Capacitor or Centigrade
COP	Computer operating properly
cm	Centimetre
cNm	Centinewton meter
csk	Countersunk
DC	Direct current
deg.	Degrees
dia.	Diameter
µg	Micro gramme
Fig.	Figure
g	Gramme
Hg	Mercury symbol
Hz	Hertz
IC	Integrated circuit
IM	Instruction manual
Kg	Kilogram
Khz	Kilo Hertz
KVO	Keep vein open
LCD	Liquid crystal display
LED	Light emitting diode
mA	Milliampere
mg	Milligramme
ml	Millilitre
mm	Millimetre
No.	Number
PCA	Patient controlled analgesia
PCB	Printed circuit board
PI	Plug
R	Resistor
RAM	Random access memory
ROM	Read only memory
V	Volts
VFD	Vacuum fluorescent display

# **CHAPTER 1**

## **INTRODUCTION, FEATURES and SPECIFICATION**

**Graseby 3100**  
Syringe Pump

# CHAPTER 1

## INTRODUCTION, FEATURES and SPECIFICATION

### Introduction

The 3100 syringe pump is microcomputer controlled and has been purpose developed for administering sterile liquids. All the controls are clearly marked and easy to use. The user is provided with a constant indication of the 3100's operation; the dot matrix Vacuum Fluorescent Display (VFD) presents the display in any one of seven major European languages.

The 3100 is a compact robust pump that can operate from a table top or a pole clamp.

The pump can be programmed by the user to work with a range of different makes of syringe and automatically senses the diameter of the syringe installed and hence its volume. The syringe sizes that the pump caters for are 20 ml, 30 ml and 50/60 ml.

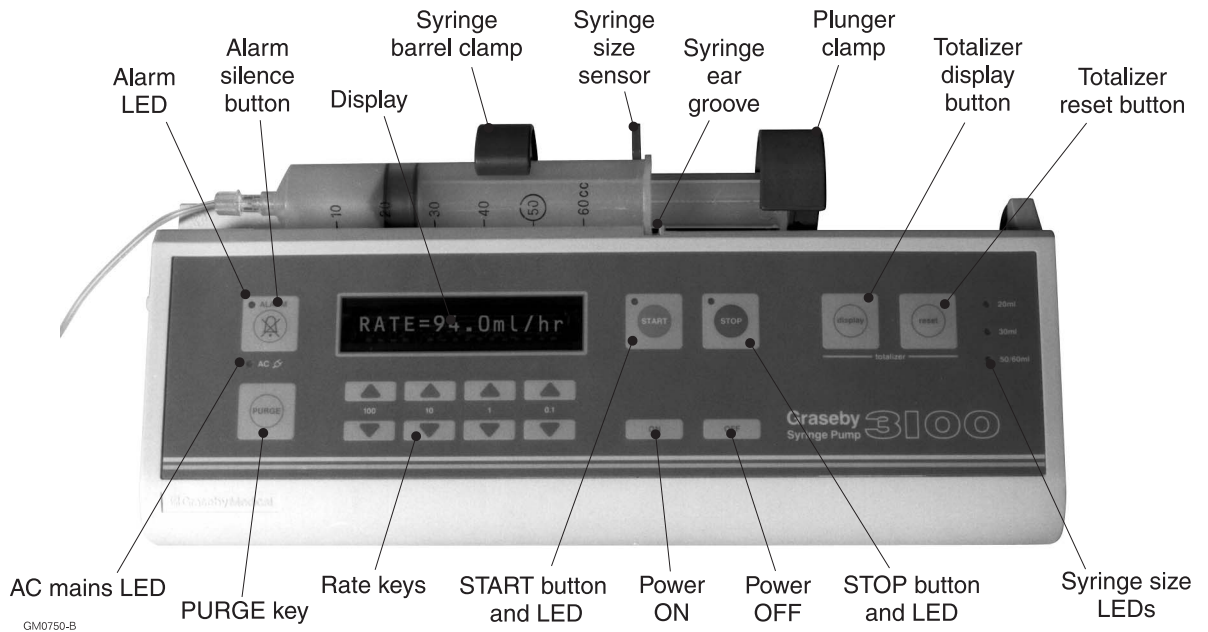


Figure 1.1 General view of the 3100 pump

## Introduction

(contd.)

The 3100 is easily configured to dispense liquids at rates between 0.1 ml/hour and 199.9 ml/hour in increments of 0.1 ml. The pump keeps a running total of the volume of infused liquid even when the infusion has been stopped and then restarted.

The pump can be operated from AC power or from three internally fixed rechargeable batteries. When running on battery power, the pump gives more than three hours of continual use. The pump contains a battery recharging circuit and the batteries will be fully charged when the pump has been connected to the AC power for up to 14 hours (see Note below) - even when the pump is switched OFF.

**Note:**

The battery charging period may have to be slightly increased above 14 hours if the pump is infusing during the charging period.

Safety features have been built into both the software and the hardware. The pump carries out a self-testing routine each time it is switched on. The user is warned of incidents such as a power failure or an occlusion by both visual and audible alarms.

Two micro-controllers are installed in the pump and are used to combine the following facilities:

- non-volatile Random Access Memory (RAM),
- analogue to digital conversion,
- communications circuitry, and
- internal watchdog, COP (Computer Operating Properly).

The above facilities are usually provided by up to six separate silicon chips. The use of highly integrated micro-controllers greatly increases the reliability of the 3100.

The motor within the pump is under the direct control of the primary micro-controller. For added security, the primary micro-controller's actions are monitored by the slave processor.

**Security cover**

An optional security cover kit is available (part number 0131-0277). The kit includes all the items required to modify the pump, including comprehensive fitting instructions. *When fitted, the kit protects the syringe from tampering only; it provides no other security. It does not lockout the keypad or give audible or visual alarms when opened.*

## Features

The main features of the 3100 are:

- simple to use,
- ergonomic styling,
- easy to service,
- AC powered or internal battery powered,
- advanced safety features,
- caters for different brands of syringe,
- automatic syringe size sensing,
- clear text display,
- comprehensive range of alarms,
- designed in consultation with users,
- drip proof (IPX1)
- state-of-the-art electronics, and
- numerous Warnings accompanied by an audible and visual alarm, including a three minute nearly empty syringe warning,
- all materials used in this product are latex free.

**Specification**

Graseby instruments are subject to continual development and may, therefore, differ from the following specification:

Dimensions:	325 mm (long) x 195 mm (high) x 115 mm (deep), with a pole clamp, and the plunger clamp closed.	
Weight:	Not exceeding 3.5 kg including batteries and pole clamp.	
Supply voltage:	220 V to 240 V AC at 50/60 Hz 15 VA or, 100 V to 120 V AC at 50/60 Hz 15 VA.	
Battery type:	Sealed lead acid, rechargeable (Cyclon, 3 off). The batteries should be checked at least annually (see page 5-11).	
Battery life:	More than 3 hours of normal pump operation when the batteries are fully charged. With the AC supply connected, up to 14 hours will be required to fully recharge low voltage batteries.	
Useable syringes:	BD Plastipak ...	Size 20; 30 or 50/60 ml.
	Braun Omnifix ...	Size 20; 30 or 50/60 ml.
	Monoject ...	Size 20, 30/35 or 50/60 ml.
	Terumo ...	Size 20; 30/35 or 50/60 ml.
	Injectomat 50 ml ...	Size 50/60 ml.
	Braun Perfusor ...	50 ml (conversion kit required, refer to Chapter 8).
Flow rate:	0.1 to 199.9 ml/hour in 0.1 ml increments.	
Volume infused counter:	0 to 999.9 ml in 0.1 ml increments.	
Adjustable occlusion pressure:	250 mm Hg to 600 mm Hg.	
Temp. range:	Operating conditions: -5° to +40°C, 30 to 75% Rh, 700 to 1060 hPa.	
	Storage conditions: -40° to +70°C, 30 to 90% Rh, 700 to 1060 hPa.	
Drive accuracy:	+/- 2%.	
Design standards:	BS 5724 Part 1. IEC 601 Part 1. VFG 1046/1984.	
Elec. safety:	Class II; Type CF; Drip proof.	
Language versions:	English, Dutch, French, German, Italian, Portugese and Spanish.	

## Brief history of Graseby bedside syringe pumps

### MS2000

The first Graseby bedside syringe pump was the **MS2000**. This was a basic syringe pump capable of infusions within the range of 0.1ml/hr to 99.9ml/hr. It had a totaliser, a limited infusion capability, a built in pole clamp and was designed for vertical operation. The MS2000 was powered by an AC supply or its internal DC batteries. This pump is no longer manufactured.

### PCAS

The **PCAS** pump was developed from the MS2000 to satisfy the growing interest in Patient Controlled Analgesia (PCA). The PCAS was very similar to the MS2000 in both appearance and mechanical design, but utilised a different microprocessor with the capability of running the extra features required for PCA and was eventually replaced by the 3300 pump. A printer port was also incorporated. This pump is no longer manufactured.

### 3000

The first pump in the 3000 Series of syringe pumps was the **3000** itself. This pump was designed as a low-cost alternative to the MS2000 and satisfied the need for a horizontally mounted pump. The 3000 did not have an internal battery supply. This pump is no longer manufactured.

### 3100

The **3100** syringe pump was developed from the 3000. It is very similar mechanically but the electronic design is superior. Dual processors were incorporated along with a vacuum fluorescent text display and internal batteries. The maximum infusion rate was increased to 199.9 ml/hr and different syringe sizes were able to be used (automatically sensed). Extra software features, such as the intelligent 'near end' alarm, were also incorporated.

### 3300

The next bedside syringe pump to be developed was the **3300**. This was similar in mechanical and electronic design to the 3100 but the features were specifically for the now more mature PCA market. A lockable syringe cover was added for security against drug theft, a four line LC display was added, and internal history recording with printout was also added. With the growth in PCA knowledge in the medical community, many more software features were incorporated into the 3300 to aid PCA administration.

### 3400

The **3400** was developed (again from the 3100) to satisfy the need for a high speed infusion pump for intravenous anaesthesia. Advances in micro-controller technology allowed the use of a single device to control all the pumps features. The maximum infusion rate was raised to 1200.0 ml/hr and bolusing facilities were also added. Later, an infusion rate calculation facility was added to the software.

A larger liquid crystal display was used on the 3400 with the ability to display text in different sizes, also 'soft-keys' were used to make the user interface simpler. The range of syringe sizes that could be used was also increased. For more advanced applications the pump could be controlled by a computer.

### 3200

The **3200** was developed as a high end general purpose syringe pump. In-line pressure sensing, intermittent infusion capabilities and computer interfacing were added. The In-line occlusion pressure monitoring made the pump particularly suitable for use in intensive care baby units. A large text vacuum fluorescent display was added and the range of increased syringe sizes of the 3400 remained.

### 3500

There are two versions of the **3500**, as detailed below:

- a Manually Controlled Infusion (MCI) *only* pump,
- a MCI *plus* a Target Controlled Infusion (TCI) pump.

The 3500 was developed from the 3400 and retains all the 3400 facilities. The 'MCI *plus* TCI' pump carries out a TCI using the Diprivan drug. This version of the 3500 incorporates a Diprifusor module manufactured by Zeneca Pharmaceuticals. A new main circuit board and new software allows the 3500 to interface with the Diprifusor module.

### 3150

The **3150** is very similar to the 3200 general purpose pump. The main difference being that the In-line pressure sensing system is **not** available on the 3150, i.e. the pressure transducer is not fitted.



# **CHAPTER 2**

## **CONFIGURATION MODE, DIAGNOSTIC MODE, and OCCLUSION MEASUREMENT**

**Graseby 3100**  
Syringe Pump

## CHAPTER 2

### CONFIGURATION MODE, DIAGNOSTIC MODE and OCCLUSION MEASUREMENT

#### Configuration mode

The Configuration mode allows both the syringe brand and the language required to be displayed and entered before using the pump.

#### Calling up the Configuration mode

##### CAUTION

**The Configuration mode procedures must only be undertaken by suitably qualified medical personnel.**

1. When in the Set-up mode (refer to the 3100 Instruction Manual), simultaneously hold down ...  
either of the extreme right hand **0.1** arrow buttons ( ▲ or ▼ ) and the **PURGE** button.

The display will show the following:

CONFIGURATION?

2. Within five seconds, press the **START** button to confirm that the Configuration mode is required. If the **START** button is not pressed within five seconds the pump will revert back to its Set-up mode.

##### Note:

The pump has been designed so that the Configuration mode will not be called up accidentally.

#### Syringe brand selection

##### WARNING

**The 3100 must be set to operate with the selected syringe. Using the wrong selection could lead to the incorrect amount of drug being administered.**

With the pump in its Configuration mode (as detailed above), complete the following procedures in order to select the syringe brand required.

1. Use either of the two extreme left hand **100** arrow buttons ( ▲ or ▼ ) to display the last syringe brand that was used.
2. Use either of the two extreme right hand **0.1** arrow buttons ( ▲ or ▼ ) in order to scroll to the syringe brand required (see below). The brand of syringe selected will be retained by the pump until the Configuration mode is called up again and a different brand is selected.
  - BD Plastipak.
  - Terumo.
  - Braun Omnifix.
  - Monoject.
  - Injectomat 50 ml.

##### Note:

The Braun Perfusor 50 ml syringe can only be used when the pump has been converted to accept this particular syringe (see Chapter 8).

3. Press the **STOP** button in order to exit the Configuration mode.

**Language setting**

With the pump in its Configuration mode (as detailed previously), complete the following procedures to select the required language.

1. Use either of the two extreme left hand **100** arrow buttons ( ▲ or ▼ ) to scroll and display the last language that was used.
2. Use either of the extreme right hand **0.1** arrow buttons ( ▲ or ▼ ) in order to scroll and display the language required (see below). The language selected will be retained by the pump until the Configuration mode is called up again and a different language is selected:
  - English
  - Dutch
  - French
  - German
  - Italian
  - Portuguese
  - Spanish
3. To exit the Configuration mode, press the **STOP** button.

**Setting the AC voltage****WARNINGS**

1. **The following procedures must only be carried out by qualified technicians.**
2. **ELECTRIC SHOCK HAZARD. The pump must be disconnected from the AC power supply before opening the casing.**

**CAUTION**

**If the AC supply voltage settings are altered the label on the underside of the pump and also the AC fuse rating must be changed to indicate and cater for the new AC voltage.**

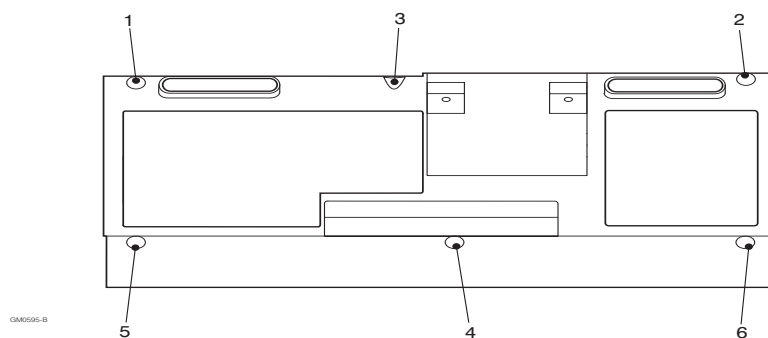
The pump can be set to operate on a 100 to 120 V or a 220 to 240 V AC 50/60 Hz supply. To change the AC operating voltage settings (as fully detailed in the following sections) the pump casing has to be opened and two push-on connectors on the Regulator board have to be adjusted.

The AC supply fuse rating must also be changed.

**Disassembly and assembly of casing**

Each time the case is taken apart, the Syringe size sensor tests (see page 6.1) must be completed.

1. Disconnect the AC power connector and using a scratch free flat surface, turn the pump over in order to gain access to its base.
2. Undo and retain the six screws that hold the casing halves together. One of the six screws is situated in a channel in the rear cover.
3. From the top of the pump carefully ease the casing halves apart, taking care not to put any strain on the internal connecting cable looms that form a hinge between the two halves.
4. Being careful not to trap any leads, assemble the casing by reversing steps (2) and (3) above. Ensure that the front and rear mating edges are equal and parallel. The screws should be tightened to a torque of between 70 and 75 cNm and in the order shown *Figure 2.1*.



Rear view of pump

Figure 2.1 Rear case screw fixing order

### AC voltage and fuse adjustment

1. Take the casing apart (see page 2-2).
2. Check/ alter the position of the two push-on connectors situated on the Regulator board (these connectors are attached to a black and a grey wire). The alternative settings are as follows:

#### 220-240 V

Grey: PL4  
Black: PL8

#### 100-120 V

Grey: PL7  
Black: PL3

3. Move the two blank insulated connectors so that they cover the two unused alternative voltage terminals.
4. Remove the cover that is placed over fuse FS2. If required fit the correct time delay fuse, as shown below:
  - T 50 mA for 220-240 V.
  - T 100 mA for 100-120 V.
5. Fit the fuse cover ensuring that the cover goes outside all of the spring connectors.
6. Assemble the casing (see page 2-2).
7. If necessary stick a new voltage label over the existing label on the underside of the pump. The new label must correctly specify the pump's present AC voltage.

### Diagnostic mode

The pump has a Diagnostic mode which enables the four following parameters to be checked:

- the version of software that is installed in the Main processor,
- the software Cyclic Redundancy Check (CRC),
- the version of software that is installed in the Slave processor, and
- the voltage from the power supply to the Main board, or with the AC removed will display the battery voltage.

The pump has been designed so that the Diagnostic mode has to be specifically keyed in. It will be very unlikely that this mode will appear on the display accidentally.

**Keying in the diagnostic mode**

By carrying out the following procedures the pump will be transferred from its Set-up mode (refer to the 3100 Instruction Manual) to its Diagnostic mode:

1. Simultaneously press and hold down the following two buttons ... the **ALARM** button and either the right hand up or down arrow button (**0.1**, **▲** or **▼**).
2. Within five seconds press the **START** button to confirm that the Diagnostic mode is required. If the **START** button is not pressed within five seconds the pump will revert back to its Set-up mode.
3. Press either the extreme left hand up or down arrow button (**100**, **▲** or **▼**) in order to scroll through the four Diagnostic parameters listed above.
4. Press the **STOP** button to exit the Diagnostic mode.

**Occlusion measurements**

The two most frequently used methods to measure the point at which an occlusion occurs are the **thrust** and **pressure** methods.

Currently, the occlusion is set at during manufacture by using a **thrust** measurement procedure. This method measures the plunger clamp thrust by using a set of weights (as described on the next page).

The occlusion **pressure** is obtained by measuring the pressure that occurs in the infusion line. This in-line method requires the use of a new syringe, infusion line and pressure gauge. Conversion between the two is achieved using the formulae below, taking into consideration syringe stiction.

The internal occlusion sensing system within the pump is always active.

The occlusion thrust checks must be carried out whenever the super nut assembly is dismantled.

**Thrust measurements**

Translation of the thrust depends on the syringe diameter and the stiction of the syringe. The formula for calculating the thrust is given below:

$$T = \frac{P \times A}{732} + S$$

where: **T** = the thrust in kg,  
**P** = the delivery pressure in mmHg,  
**A** = the cross sectional area of the syringe in cm<sup>2</sup>,  
and **S** = the syringe stiction in kg.

The occlusion thrust of the pump is factory set to be between two limits (i.e. a minimum and a maximum tolerance). The customer may reset the thrust for their own particular requirement. The thrust of a particular pump may, therefore, differ from the original factory set level.

The occlusion thrust of the **3100** pump is factory set at between 3.5 kg and 4.2 kg (471 mmHg and 565 mmHg).

**Syringe stiction**

Stiction for a syringe varies from brand to brand as well as from batch to batch. Stiction can be as low as 0.1 kg and as high as 2 kg. The stiction of some syringe brands has been found to be particularly high.

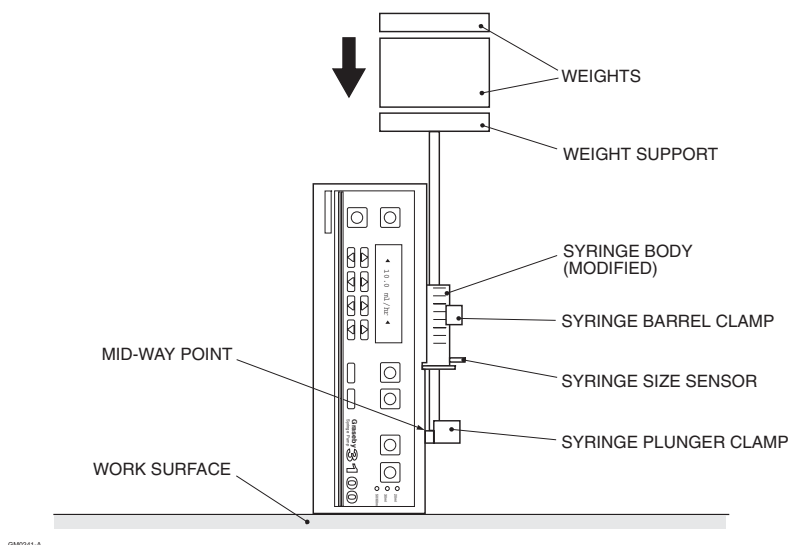
Stiction can also vary along the plunger travel and is usually lowest in small diameter syringes. Using a sample syringe and allowing for a safety margin for sticky syringes, adjustments can be made by measuring the thrust generated. If the stiction characteristics of a syringe are known then by using the formula given above the occlusion thrust can be set.

### Thrust checks

The following thrust checks detailed use the weights that correspond to the factory set occlusion threshold levels for a 3100 (i.e. 3.5 and 4.2 kg). If a different occlusion level setting is required, the weights must be adjusted accordingly.

The threshold level adjustment procedures are detailed on page 2-6.

1. Set the pump's plunger clamp to approximately midway along its support tube.
2. Remove the plunger from a BD 60 ml syringe and then saw the end off the syringe. Place the modified syringe onto the pump so that it acts as a guide for the weight support rod and also position the size sensor flag (see *Figure 2-2*).
3. With the pump switched **ON**, set the infusion rate to 200 ml/hr.
4. Place the pump in a vertical position, with its left hand side uppermost (see *Figure 2-2*).
5. Place the weight support rod through the modified syringe and onto the pump's plunger clamp.
6. Place a weight of 3.5 kg on top of the weight support and check that the pump operates for at least 30 seconds and does **not** occlude (i.e. the alarm does not sound). Remove the weight.
7. Place a weight of 4.2 kg on top of the weight support and check that within 60 seconds the pump does occlude (i.e. the alarm sounds).



*Figure 2.2 Thrust measuring set up*

**Thrust adjustments**

If the occlusion thrust requires adjustment, the following procedures must be completed:

1. Switch the pump off and disconnect the AC supply.
2. Take the casing apart (see page 2-2).
3. If necessary rotate the leadscrew to reveal the grub screw that is located on the occlusion adjusting nut. Loosen the grub screw with a 1.5 mm hexagonal key.
4. Alter the setting of the occlusion adjusting nut as necessary. One full turn of the adjusting nut gives approximately 2.73 kg (369 mmHg) of adjustment.  
  
Rotating the adjusting nut in order to decrease the tension on the leadscrew spring will decrease the pump's occlusion setting.  
  
Rotating the adjusting nut in order to increase the tension on the leadscrew spring will increase the pump's occlusion setting.
5. Tighten the grub screw to a torque of  $15 \pm 2$  cNm.
6. Temporarily assemble the two halves of the pump, being careful not to trap any leads.
7. Carry out a thrust check (see page 2-5).
8. In order to obtain the thrust required it may be necessary to repeat steps (2) to (7) above.
9. Finalise the Assembly of the pump casing (refer to page 2-2).
10. Carry out the tests listed below and fully detailed in the functional test procedures (see page 6-1 onwards):
  - Test 4 ... syringe size sensors,
  - Test 7 ... accuracy of infusion,
  - Test 9 ... plunger clamp alignment, and
  - Test 10 ... clamp open.

# **CHAPTER 3**

## **FUNCTIONAL DESCRIPTIONS**

**Graseby 3100**  
Syringe Pump



## CHAPTER 3

### FUNCTIONAL DESCRIPTIONS

This Chapter explains how the 3100 operates. Reading this chapter will help a technician to rectify any possible faults that may occur within the pump.

The functional descriptions of the pump may be divided into five separate areas, and each of these functional descriptions has been detailed separately in the descriptions that follow:

- Drive system,
- Occlusion sensing system,
- Electro/mechanical control system,
- Sensing (alarm) systems,
- Software.

#### Drive system

The drive system comprises a stepper-motor working through a gearbox in order to rotate a leadscrew. A half nut/ super nut assembly engages onto the leadscrew; the assembly is also connected to a steel tube. The steel tube is connected to the plunger clamp. Thus the rotation of the leadscrew will move the plunger clamp and this movement will push 'in' the plunger on the syringe that is being used, as further described below.

As the stepper-motor spindle rotates the leadscrew rotates and the half nut/ super nut assembly travels to the left, along the leadscrew. The half nut/ super nut assembly pulls the outer of two steel tubes to the left. This outer tube travels over and along a support tube; the support tube is the length of the pump.

The pulses applied to the stepper-motor are derived from a microcomputer. The microcomputer and its associated software determines the speed of the stepper-motor. To ensure safe operation of the stepper-motor the microcomputer controls the stepper-motor directly.

A spring-loaded toggle mechanism is attached to the bottom of the half nut. This toggle mechanism enables the plunger clamp to be physically swung 'in or out' thus rotating the outer metal tube so that the half nut is either fully 'engaged or disengaged' (respectively) from the leadscrew.

When the plunger clamp is pushed 'in', the half nut/ super nut engages with the leadscrew and the pump's plunger clamp 'grabs' the end of the syringe. The syringe plunger slots into place behind a slotted pair of lips. These lips prevent the syringe plunger from moving forward in the event of negative pressure on the syringe.

A small push-button on the edge of the plunger clamp makes contact with the top of the syringe plunger. This push-button controls the operation of a lever which projects from the plunger clamp. When the push-button is pressed in, by coming into direct contact with the top of the syringe, the lever becomes free and is able to retract into the plunger clamp. This retraction takes place when the plunger clamp is physically swung into the forward operating position.

(contd.)

**Drive system** (contd.)

If the push-button is not pressed 'in', the lever remains in its outward position thus preventing the plunger clamp from being moved. This in turn prevents the half nut from engaging on the leadscrew. This push-button system prevents the leadscrew from being engaged unless the top of the syringe is correctly positioned in the plunger clamp.

If the plunger clamp is accidentally knocked out of place during an infusion it will automatically and safely shut down and an alarm will sound.

The motor, gearbox, leadscrew and associated components are mounted on a glass reinforced polycarbonate casing. The strength of this casing enables a precise mechanical location to be achieved for the components. Both the inner and outer metal tubes are made of substantial material in order to eliminate all unwanted flexing.

**Occlusion sensing system****Clutch assembly and opto-sensor**

The occlusion sensing system consists of a clutch, spring mechanism, a rotating slotted disk and opto OPTO1 (see page 7.10). The clutch and spring mechanism comprise the back pressure system. The rotating slotted disc and OPTO1 comprise the rotation detector. The clutch, slotted disc and OPTO1 are located at the left hand end of the leadscrew, underneath the opto sensor board. The spring is located at the right hand end of the leadscrew.

The clutch is held engaged by the spring with a pressure sufficient to overcome any resistance from the syringe plunger and the normal back pressure from the infusion line. The rotation detector will generate an output that comprises a continuous set of pulses when the leadscrew rotates.

**Occlusion detection**

If there is an occlusion in the line then the back pressure will rise as the pump attempts to force fluid through the line. When there is sufficient pressure to overcome the spring pressure (factory set at 500 mm Hg) then the leadscrew moves to the right, losing contact with the clutch. The rotation detector no longer generates an output, which results in an occlusion alarm.

This method of occlusion detection is extremely sensitive as it is the lack of pressure on the clutch that generates the alarm, rather than the detection of the movement of the leadscrew as used in traditional designs. UK patent number 2249 497.

**Electro/mech. control system**

The microcomputer produces the pulse train for the stepper-motor in order to produce a set flow rate. The rotation of the leadscrew slotted disc (described above) is monitored by the movement of the slots and detected by the opto-sensor. If the appropriate pulses are 'not' detected by the opto-sensor then an alarm signal is generated.

Brief mechanical characteristics of the system are:

- motor step angle ... 15 degrees,
- gearbox reduction angle ... 210:1,
- number of motor steps per revolution of leadscrew ... 5,040 at all times,
- leadscrew pitch ... 5 mm, and
- syringe characteristics ... 1 ml/ 1.8 mm (BD 60 ml syringe).

**Sensing (alarm) systems**

In addition to the occlusion sensing system (see page 3-2) the following sensing systems are also operative within the 3100.

**Syringe nearly empty**

A metal flag protrudes from the left hand side of the half nut (in parallel with the leadscrew), this is the nearly empty flag. When this flag deactivates OPTO 0 (see *Figures 4.10 and 7.5*) that is situated at the left hand side of the leadscrew, and the slotted disc is still rotating, then the processor makes a calculation that depends on the infusion rate, and issues an alarm three minutes before the end of the infusion.

Also, when the processor detects that OPTO 0 is deactivated, and the slotted disc has also stopped rotating, then a OCCLUSION alarm is generated.

**End of infusion/occlusion**

Although the above condition has been termed an alarm state, the same conditions will occur when the syringe reaches the end of its travel at the end of a perfectly normal infusion.

If the slotted disc stops rotating and the nearly-empty flag has **not** moved a sufficient distance to the left to deactivate OPTO 0 then the alarm condition will be that of occlusion (see page 3-2).

**AC power failure**

The sensing system is able to detect an AC power failure. The pump will continue to run after a power failure for a period of three hours or more, by automatically switching over to its internal battery supply.

**Battery voltage low**

The sensing system also monitors the output of the batteries and registers an alarm if the voltage of the batteries drops below 5.75 V.

If the voltage falls below 5.4 V the pump will turn itself off after an initial warning period.

**Self tests/pump malfunction**

Various 'self tests' are carried out on the pump when it is first switched on. In addition to the self tests the rotation of the slotted disc at the end of the leadscrew is monitored to ensure that the drive mechanism is operating correctly. The software continually checks itself for the validity of calculations.

**Drive disengaged/syringe not fitted**

The drive system is designed so that it is only engaged when the top of the syringe is correctly positioned in the plunger clamp. If the plunger clamp is knocked out of place during an infusion the drive will automatically stop (the disengagement of the half nut is detected by an opto-sensor). Also, trying to operate the 3100 without a syringe or with a syringe incorrectly fitted will cause the pump to go into an alarm state.

**Syringe size sensors**

The pump has a syringe size sensor flag which rests on the barrel of the loaded syringe in order to measure its diameter. This spring retained sensor flag moves up and down in a bottom case groove. The bottom of the flag moves in-and-out between two opto sensors (depending upon the diameter of the syringe) and this action results in four sensor conditions being available:

- top opto sensed ... no syringe,
- neither opto sensed ... 20 ml syringe,
- bottom opto sensed ... 30 ml syringe,
- both opto's sensed ... 50 ml syringe.

**Software**

The software has been designed using the latest structured design methods and incorporates many safety tests and consistency checks. The source code for the Main processor is written in Modula 2 which is particularly suitable for safety-critical design. The Slave processor is programmed in Assembler language.

The self tests include the following:

- ROM test (CRC-16),
- RAM test,
- power supply voltage test,
- keyboard test. This test checks for shorted keys,
- stack usage test, and the
- motor windings continuity test.

The Main processor carries out most of the safety critical functions and is solely responsible for the motor rate calculations.

The Slave processor generates the characters for the display, scans the keyboard and drives most of the Light Emitting Diodes (LED). The Slave processor also runs a software watchdog which checks the Main processor.

The Configuration settings are stored in the EEPROM in the Main processor.

# **CHAPTER 4**

## **CIRCUIT DESCRIPTIONS**

**Graseby 3100**  
Syringe Pump

## CHAPTER 4

### CIRCUIT DESCRIPTIONS

This Chapter describes the action of the circuits that are used to operate the 3100 and also shows the associated circuit diagrams and the associated circuit board layouts.

The 3100 contains four separate circuit boards:

- Main board,
- Regulator board,
- Syringe size sensors board, and the
- Opto sensors board.

The overall block diagram for the 3100, showing the interconnections between the various circuits is shown in *Figure 4.1*.

The Syringe size sensors board (*Figures 4.9 and 7.6*) and the Opto sensors board (*Figures 4.10 and 7.5*) provide a mounting base for the sensors and also junction points for the sensor outputs.

#### Main board circuit

The Main board circuit is shown in *Figure 4.2* and comprises the following sub-circuits. These sub-circuits are individually described in the sections that follow:

- Processor core,
- Motor interface,
- Power control,
- Sensors interface,
- Communications processor.

#### Processor core circuit

The Processor core circuit (*Figure 4.3*) forms part of the Main board circuit and is used to process all the 'operating activities' of the pump.

The Main microprocessor chip (IC4) has an on-chip EEPROM, which stores the latest settings. IC4 also incorporates an on-board RAM; an Analogue to Digital converter (A to D); timing circuitry; communications circuitry and internal watchdog.

The chip IC3 and its associated components C7, C8 and R10 form a reset circuit. The reset output is fed to pin 17 of the IC4. On power-up this reset circuit holds pin 17 *low* in order to reset IC4, and on power-down it also holds pin 17 *low* to avoid spurious activity.

X1 and its associated components R11, C9 and C10 form an 8 MHz oscillator circuit that provides clock pulses for IC4 via pins 6 and 7.

The input to pins 2 and 3 of IC4 controls the mode of operation of IC4. Both pins are held *high* in order to set the processor ready to address the external EPROM, IC5.

The EPROM chip IC5 stores the system's software.

The reference points for IC4's built-in A to D converter are pin 67 (GRND) and pin 68 (Vcc).

A Non Maskable Interrupt (NMI) signal is generated by the Slave processor (IC7, *Figure 4.7*) and is routed via pin 18 of IC4. This NMI signal is generated when a system fault is detected.

IC4 controls the output to the stepper motor via pins 36 to 39.

D4, D5 and D6 are three LED's that are used to indicate the syringe size, as detected from the input on pins 60 and 65 of IC4. The LED's are controlled by the outputs from IC4 on pins 25, 26 and 27, which are routed to the circuits associated with D4, D5 and D6 (i.e. Q4, Q5 and Q6).

(contd.)

**Motor interface circuit**

The stepper motor interface circuit (*Figure 4.4*) is controlled by pulses supplied from the Main processor (IC4), in a set sequence.

Four motor control lines feed to four NOR gates and each NOR gate generates a *high* pulse. These pulses are used to switch four power MOSFETS (Q7 to Q10) in order to drive the stepper motor. Diodes D7 to D10 provide a discharge path for the current that is stored in the motor coils (L3 to L6) when the MOSFETS are switched off.

R27 and R67 enable the Main processor to detect the current flowing through Q7 and Q8 (MOTORSENSE 2 signal) and Q9 and Q10 (MOTORSENSE 1 signal).

If the Slave processor (IC7) detects a problem, it sends a DISABLE MOTOR pulse to the NOR gates, and also sends a Non Masterable Interrupt (NMI) signal to the Main processor. The output from each NOR gate is forced *low* (irrespective of the control pulses from the Main processor) thus disabling the stepper motor.

**Power control circuit**

Power from the Regulator board is routed to the Power control circuit via plug PL1 (*Figure 4.5*). D1 is an AC power on LED that is illuminated whenever the AC power is switched ON.

IC1 is a linear regulator which provides a 5 V supply ( $V_{cc}$ ) for the logic circuits. C1, C2 and C3 act as decoupling capacitors.

R7, R8, R9 and Q3 allow the Main processor to detect the presence or absence of AC power (e.g. if the AC\_SENSE line is low it indicates that the AC power is present).

IC2B and IC2C form a set/reset latch to operate the power MOSFET Q1. The latch is triggered by a high pulse from the Main processor (POWER OFF), causing Q1 to turn off and disconnect the power. Once tripped the latch cannot be reset by the Main processor but must be reset by a high pulse by pressing the ON button.

Q2, R3, R4 and R6 form a logic level translator to translate 0 to 5 V logic levels into

0 to 7 V logic levels ( $V_{DD}$ ) for IC2. C4 and C5 overcome the effects of any transients. D2 prevents C4 from discharging into IC2B.

**Sensors interface circuit**

Connections from plug PL6 and PL7 (*Figure 4.6*) connect to the Size sensors (syringe) circuit and the Opto sensors circuit, respectively.

When triggered by a SENSOR ENABLE pulse from the Main processor a constant current circuit (Q18 and Q19) turns *on* so that  $V_{IN}$  is applied across the LED opto-sensors. The outputs from any of the triggered opto-detectors is read into the Main processor's on-board A to D converter.

The sensors interface circuit also contains a battery sensing circuit to detect when the output voltage of the batteries is low. R55 and R56 act as a potential divider to  $V_{IN}$ , allowing the divided VOLTAGE SENSE output level to be fed to the A to D converter of the Main processor.

### Communications processor circuit

The communications processor circuit (*Figure 4.7*) is the communications link between the display; the **ALARM**, **START** and **STOP** LED's; the sounder and the membrane switch panel. This circuit also contains a software watchdog that monitors the operation of the Main processor, (IC4).

R28, R29 and Q11 act as a buffer circuit such that pin 1 of the Slave processor (IC7) is able to receive a *low* **RESET** pulse from the reset controller, but internally generated reset pulses will be prevented from effecting the Main processor.

X2, R30, C17 and C18 form a 4 MHz oscillator in order to provide clock pulses for IC7.

Outputs from IC7 on pins 9 to 12 are used to strobe the membrane switch panel (active *low*) by using a 4 x 4 matrix circuit. Data from the switch panel is routed via PL6 to pins 5 to 8 of IC7. Diodes D29 to D36 protect the circuit from static discharges induced into the panel.

Three outputs from pins 24 to 26 of IC7 control the **ALARM**, **START** and **STOP** LED's. These three *outputs* are fed to three transistors, Q14, Q15 and Q16, and when an *output* goes *high*, one of these transistor conducts, causing current to flow through one of the three LED's; D21 (**ALARM**), D22 (**START**) or D23 (**STOP**).

There is a serial link between IC7 and the Main processor which acts as follows. The Main processor supplies a command every 40 ms. If this command is not received a **DISABLE MOTOR** signal appears at pin 31 of IC7, and this signal is used to create a Non Maskable Interrupt (NMI) signal which is fed to the Main processor.

IC7 also controls the operation of the sounder. When pin 28 goes *low*, Q12 is turned on and Vcc is applied to the sounder via plug PL4.

Diode D19 allows the NMI signal to immediately turn on the sounder during a fault condition. D20 protects the circuit against any reverse voltage that might appear from the sounder.

Pin 13 and 19 of IC7 provide interface connections to the display circuit via plug PL5.

### Regulator board circuit

The Regulator board circuit is shown in Fig. 4.8. This power circuit provides 7 V DC for both the motor and the various LED's, and is also used to provide the 5 V DC supply to the logic circuits. The circuit is based around a TL594 chip (IC1) which is a standard step-down switching regulator chip that operates at 40 K Hz and acts as a pulse width modulating converter.

The Regulator circuit is protected by an AC power input fuse, FS2 (see page 5-3), and the AC input is filtered by C1. The two primary windings of the input transformer are connected in series when the AC supply is 230 V, and in parallel when the AC supply is 110 V. The primary terminals are PL3, PL4 and PL7 to PL10, and the secondary terminals are PL5 and PL6 (20 V rms).

PL4 and PL8 are used when the input supply is between 220 V and 240 V, and terminals PL3 and PL7 are used when the AC supply is between 110 V and 120 V. VDR1 and L2 suppress all transients.

Diodes D4 to D7 act as a bridge rectifier, and smoothing is accomplished by capacitor C4. The bridge DC output across C4 is between 25 V and 35 V DC. DC power (Vcc) is applied to pin 12 of IC1 via protection fuse FS1 (500 mA). The frequency of IC1's on-board oscillator is controlled by C6 and R3.

The IC1 outputs at pins 8 and 11 control the operation of transistor Q1. Q1 cycles on and off such that its mean output voltage is 7 V. As Q1 turns off, the voltage across the switching inductor L1 charges C3 via flyback diode D2. A feedback voltage is applied to pin 1 of IC1 via a potential divider comprising R1, TH1, R9, RV1 and R8. TH1 provides a temperature controlled output voltage to compensate for the varying battery characteristics.



C2 acts a decoupling capacitor, and the Zener diode D1 acts as a 'crowbar' protection diode for all externally connected circuits, in the event that the Regulator power circuit malfunctions. Fuse FS3 (1A) acts as a batteries protection fuse. The three rechargeable batteries, nominally 2 volts per battery, are connected in series via plug PL12 on the Regulator board.

### Plug PL11 outputs

The outputs at plug PL11 should be as shown in Table 4.1:

**Table 4.1 Plug PL11 outputs**

Pin	Output
1 and 2	Ground.
3	7 V DC, when on AC or battery supply.
4	7 V, when on AC supply.

### Setting RV1

The procedure for setting RV1 is as follows:

1. Switch off the external AC power, remove the AC power connector and open the casing (see page 2-3).
2. Remove plug PL11 and PL12 from the Regulator board and connect a 68 ohm, 1 watt resistive load across pins 2 and 3 of plug PL11. Pin 1 of PL11 is the top pin, as shown on the Regulator component layout diagram, *Figure 7.8*.

**Note:**

A Molex connector (*part number 0053-0658*) will enable the 68 ohm resistor to be easily connected across PL11.

3. Connect and switch on the AC power. If necessary, adjust RV1 to give an AC voltage across the 68 ohm load, dependent on the temperature, as shown in *Table 4.2*. RV1 is located near the top left hand corner of the board (see *Figure 7.8*).
4. Switch off the AC power; remove the 68 ohm load; reconnect PL11 and PL12 to the Regulator board and assemble the casing as detailed on page 2-3.

Table 4.2 Temperature/voltage range for setting RV1

Ambient temperature (degrees Centigrade)	DC output voltage (68 ohm load)
28	7.015
27	7.027
26	7.038
25	7.050
24	7.062
23	7.073
22	7.085
21	7.096
20	7.108
19	7.120
18	7.131
17	7.143
16	7.154
15	7.166

### Syringe size sensors

The Syringe size sensors board (*Figure 7.6*) is located just in front of the right hand end of the leadscrew. The sensor moulding houses two infrared emitting diodes and two photo-transistors.

These two pairs of detection sensors (*Figure 4.9*) are used to determine if a syringe has been loaded onto the pump (no syringe then alarm condition). If a syringe has been loaded then the sensors are able to determine the size of the syringe,

i.e. **20 ml; 30 ml** or **50/60 ml**.

The sensors are hard-wired from plug PL1 on the Size sensors board via a cable-loom to plug PL6 on the Main board.

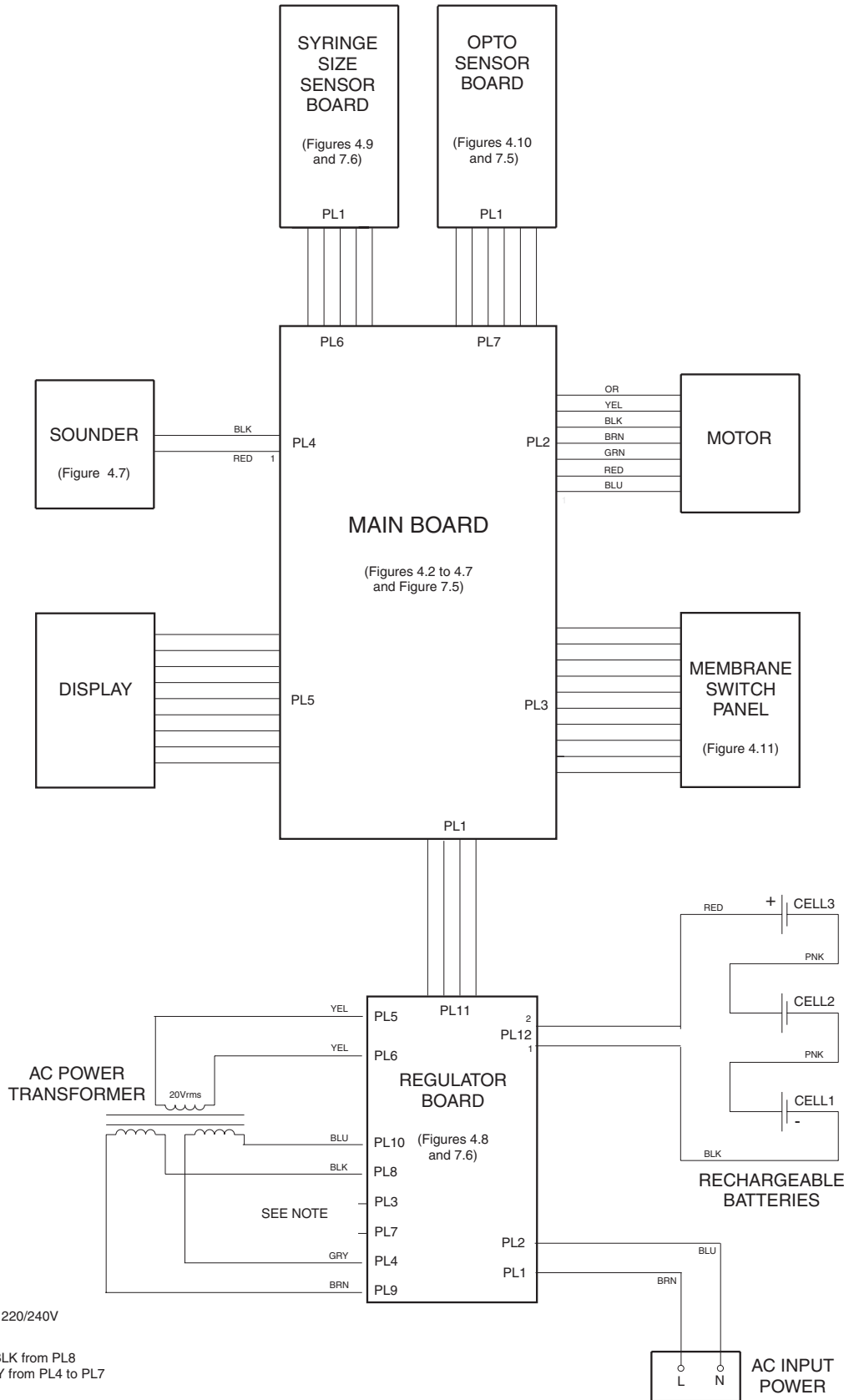
### Opto sensors

The Opto sensors board (*Figure 7.5*) is located on the left hand side of the pump just above the left hand end of the leadscrew. There are three optical interrupt devices attached to this board.

The three optical sensors (opto interrupter 0, 1 and 2; *Figure 4.10*) are used to monitor the status of the three following parameters:

- end of syringe travel detection,
- occlusion detection,
- drive engagement/disengagement detection (half nut on/off leadscrew).

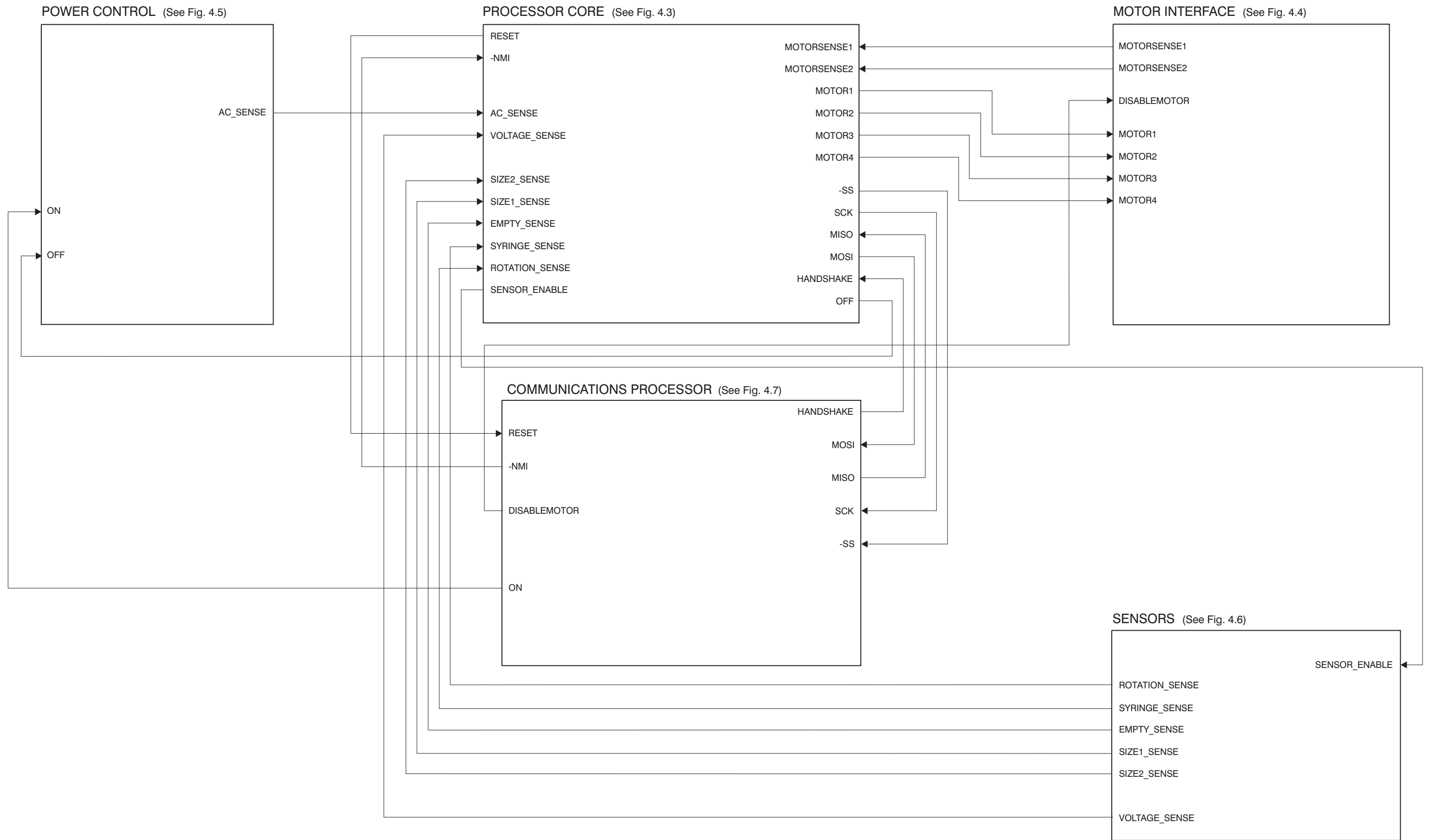
The sensors are hard-wired from plug PL1 on the Opto board via a cable-loom to plug PL7 on the Main board.



GM0197-C

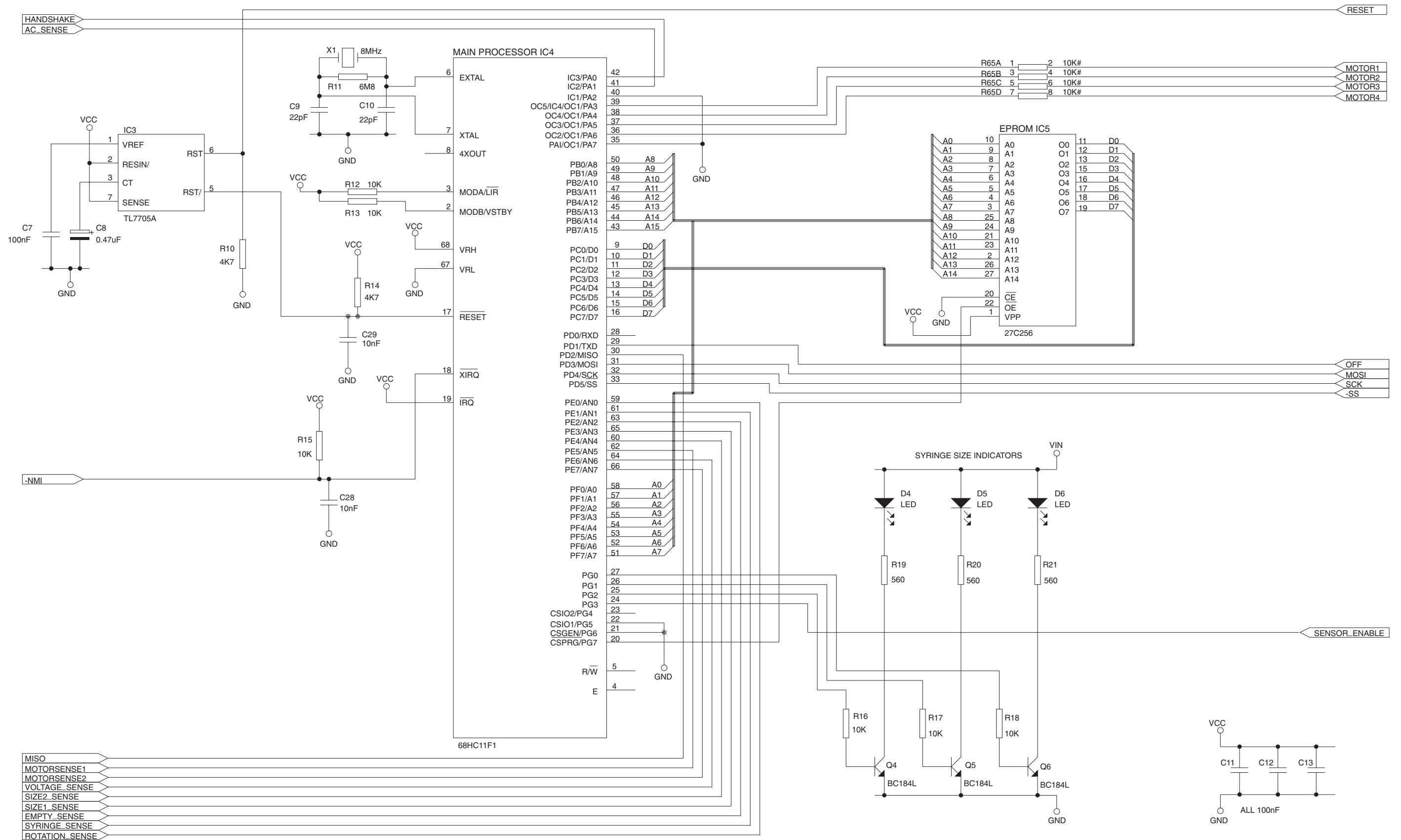
Figure 4.1 Overall block diagram





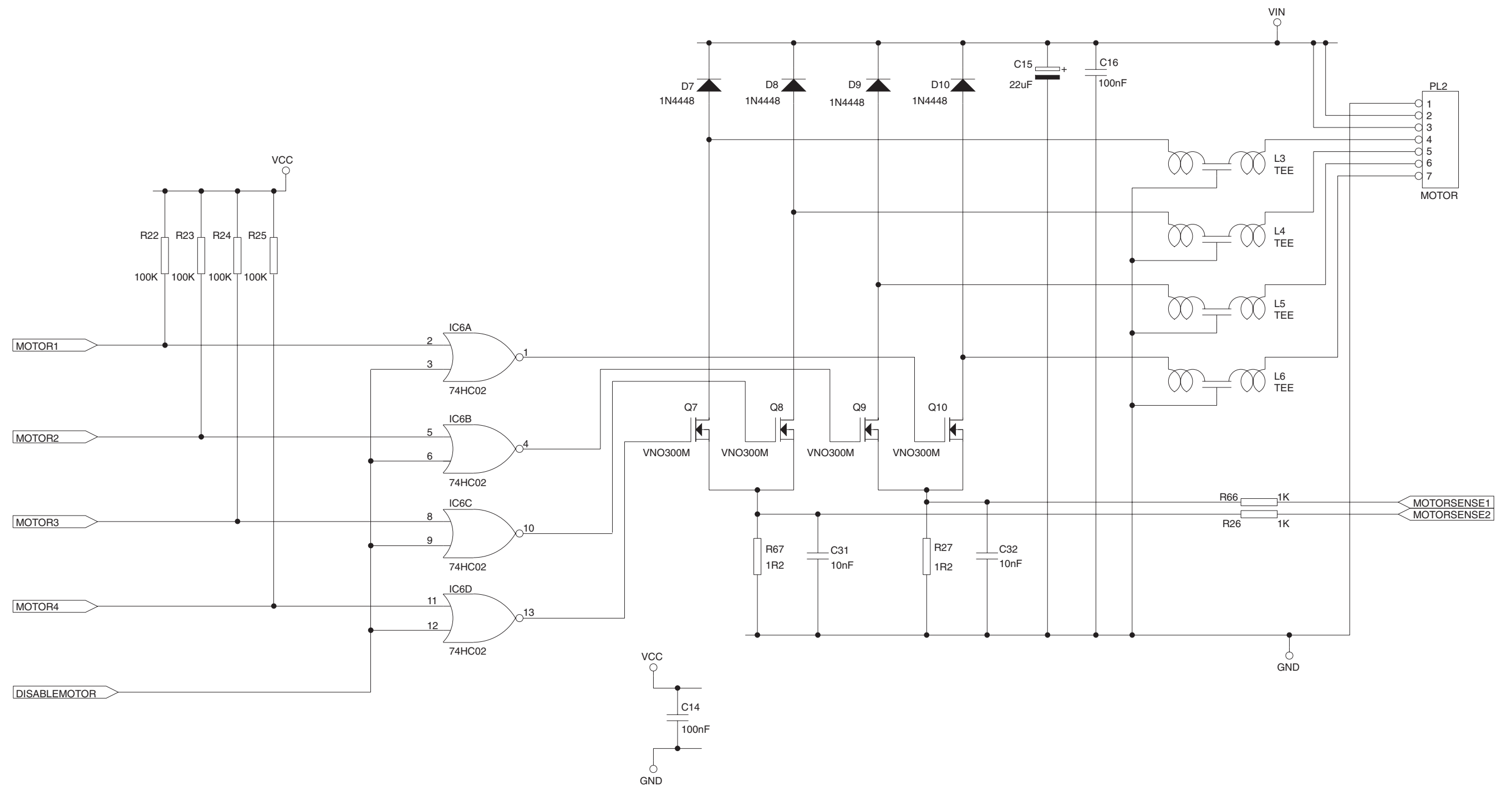
GM0191-A

Figure 4.2 Main board block diagram



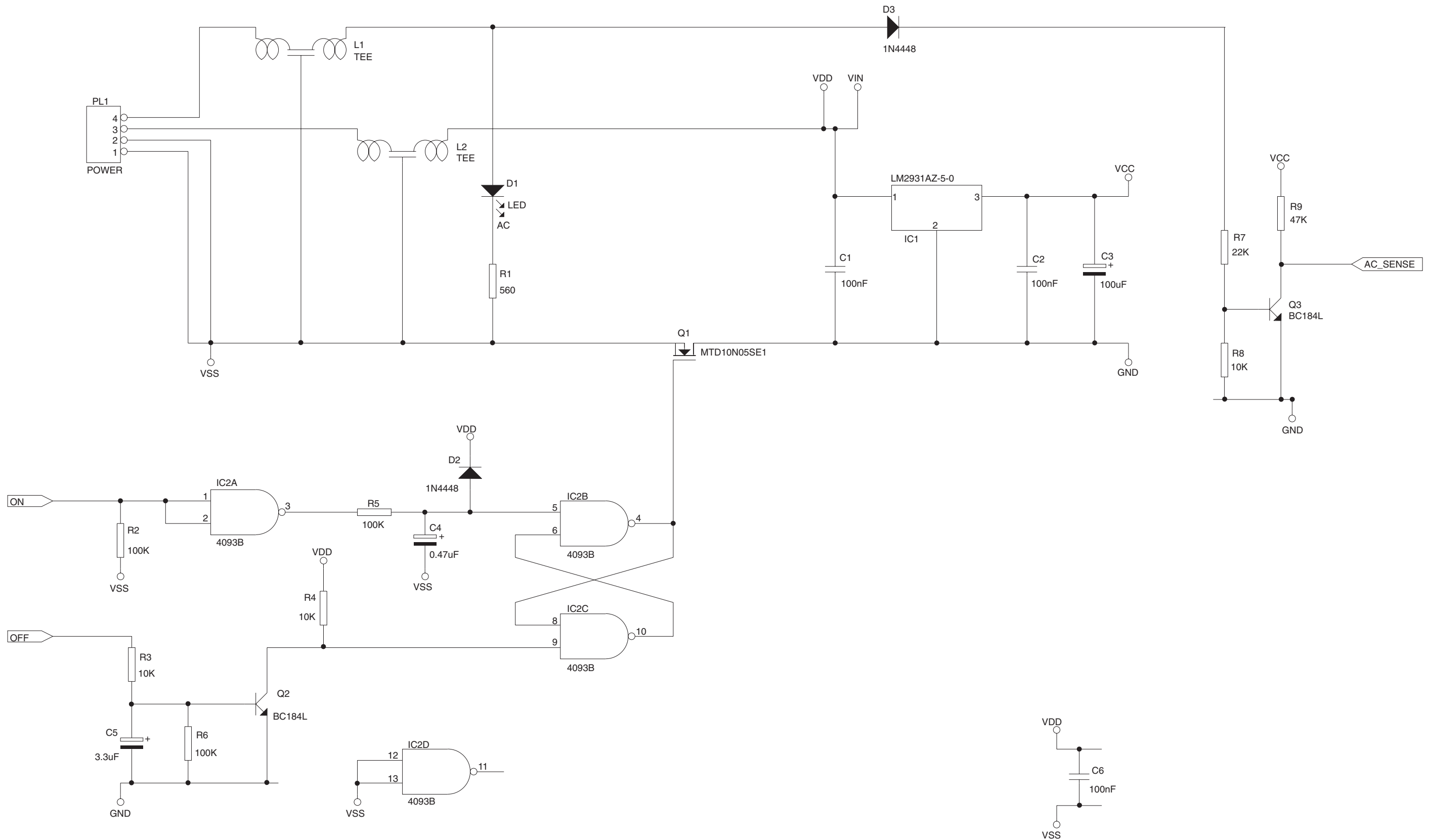
GM0193

Figure 4.3 Processor core circuit diagram



GM0195-A

Figure 4.4 Motor interface circuit diagram

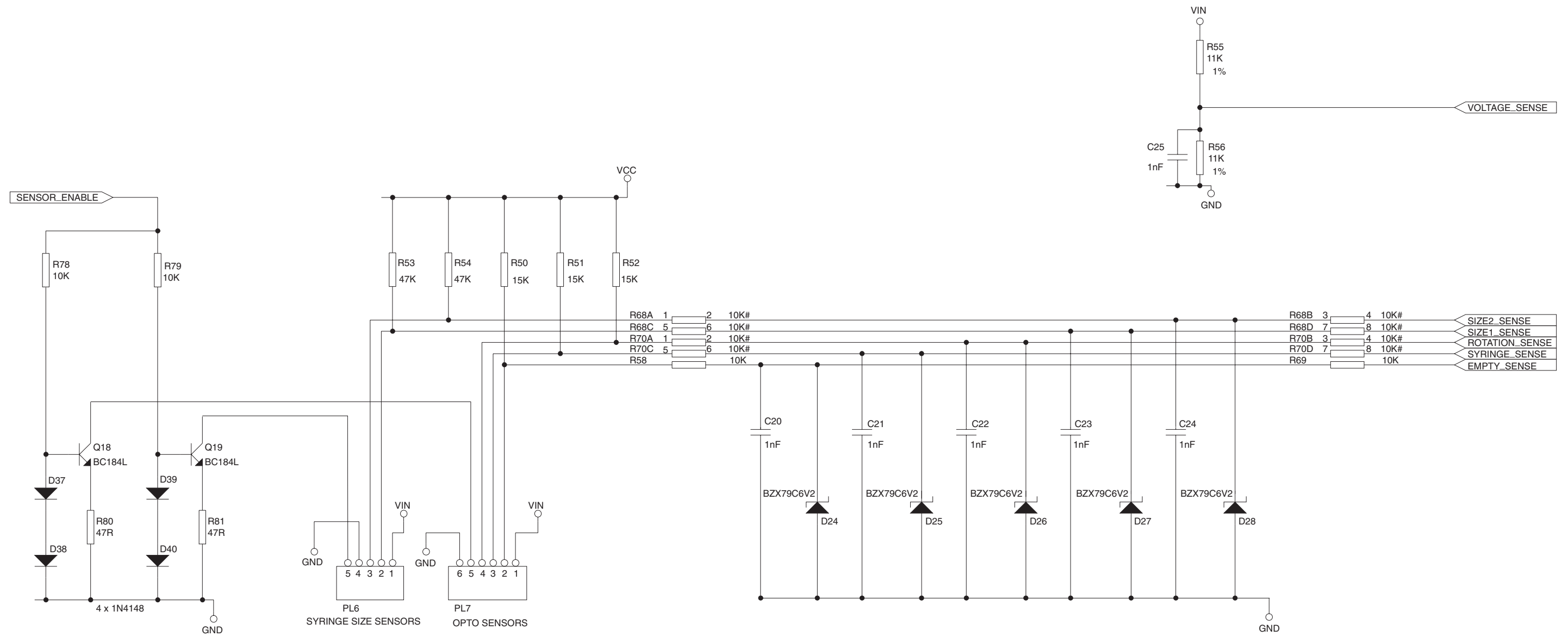


GM0192-A

4093B IS POWERED FROM VDD AND VSS

Figure 4.5 Power control circuit diagram





GM0196-A

Figure 4.6 Sensors interface circuit diagram

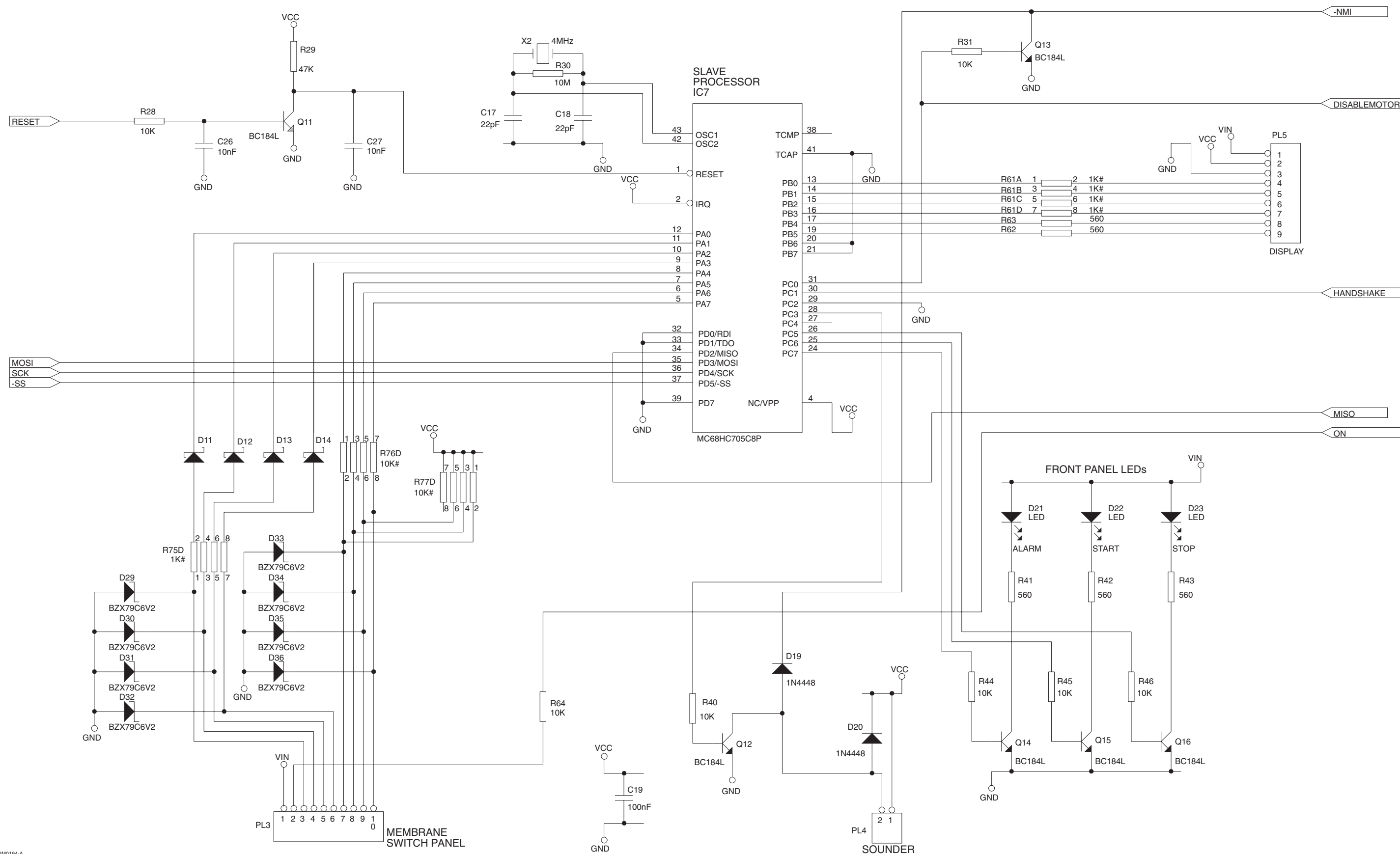


Figure 4.7 Communications processor circuit diagram

ALL RESISTORS +/- 5% UNLESS OTHERWISE STATED

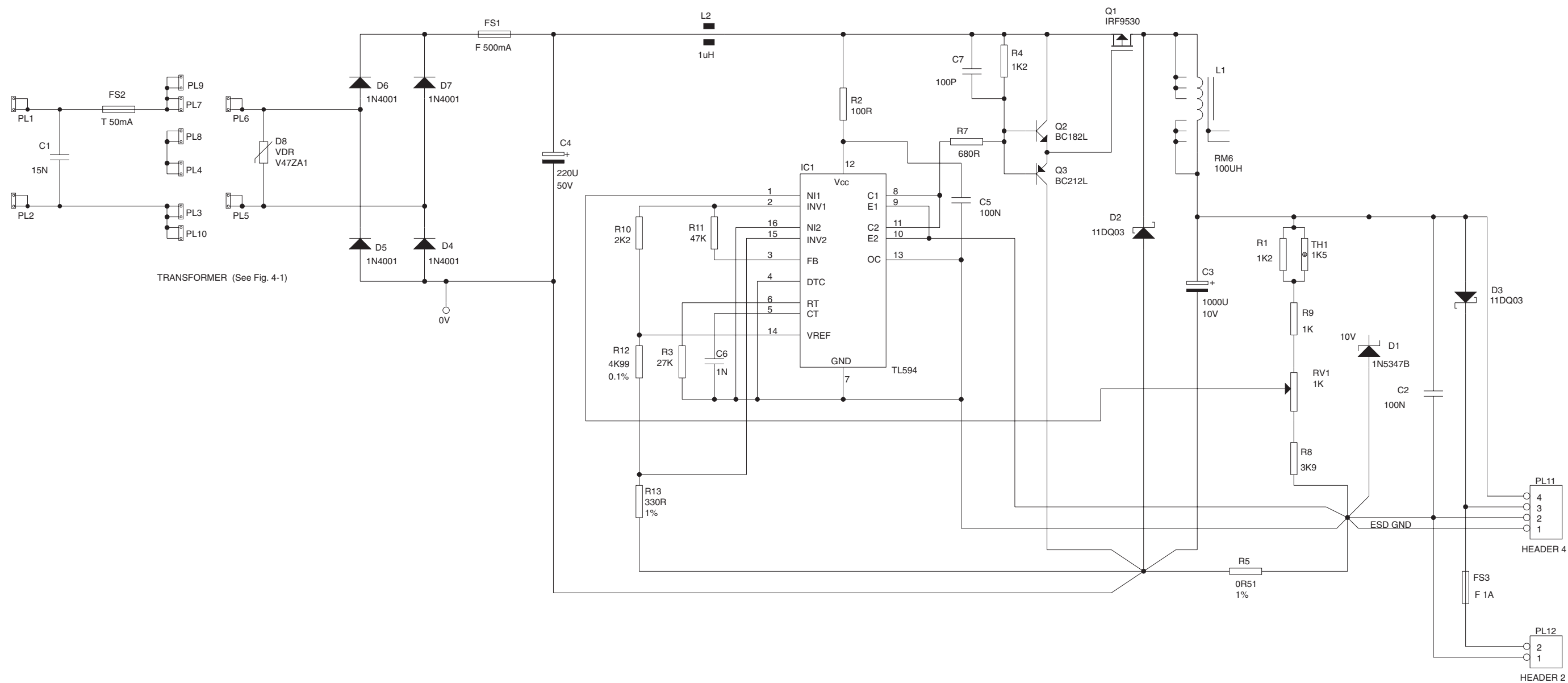
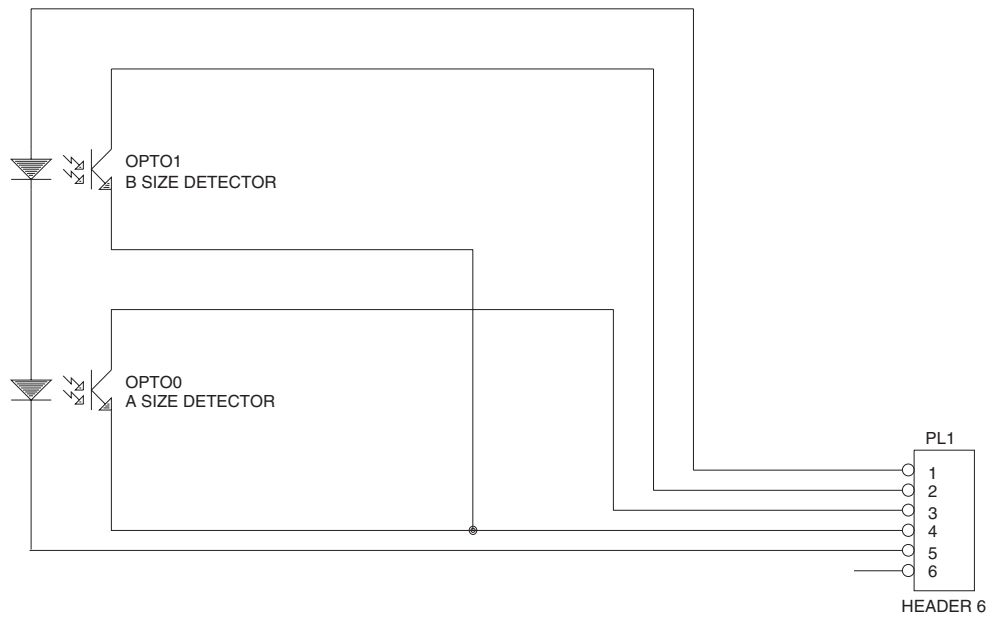


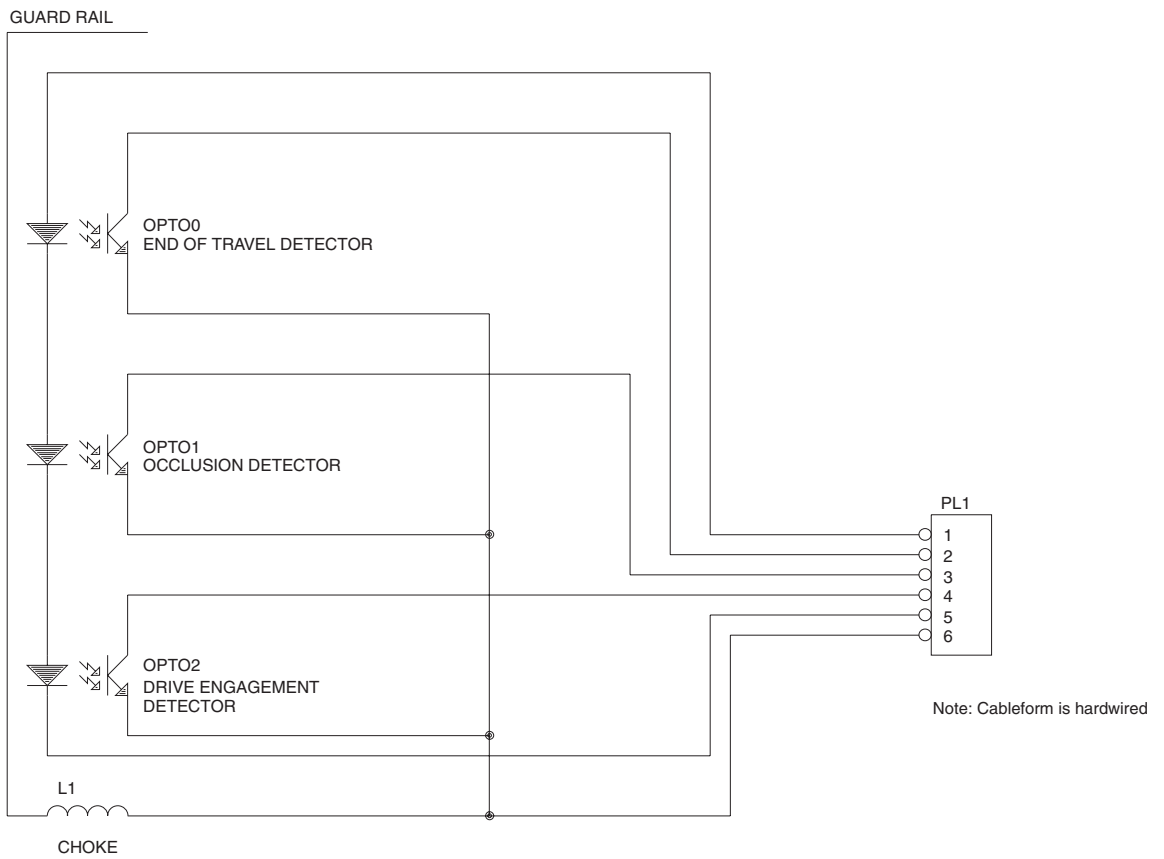
Figure 4.8 Regulator board circuit diagram





GM0094-A

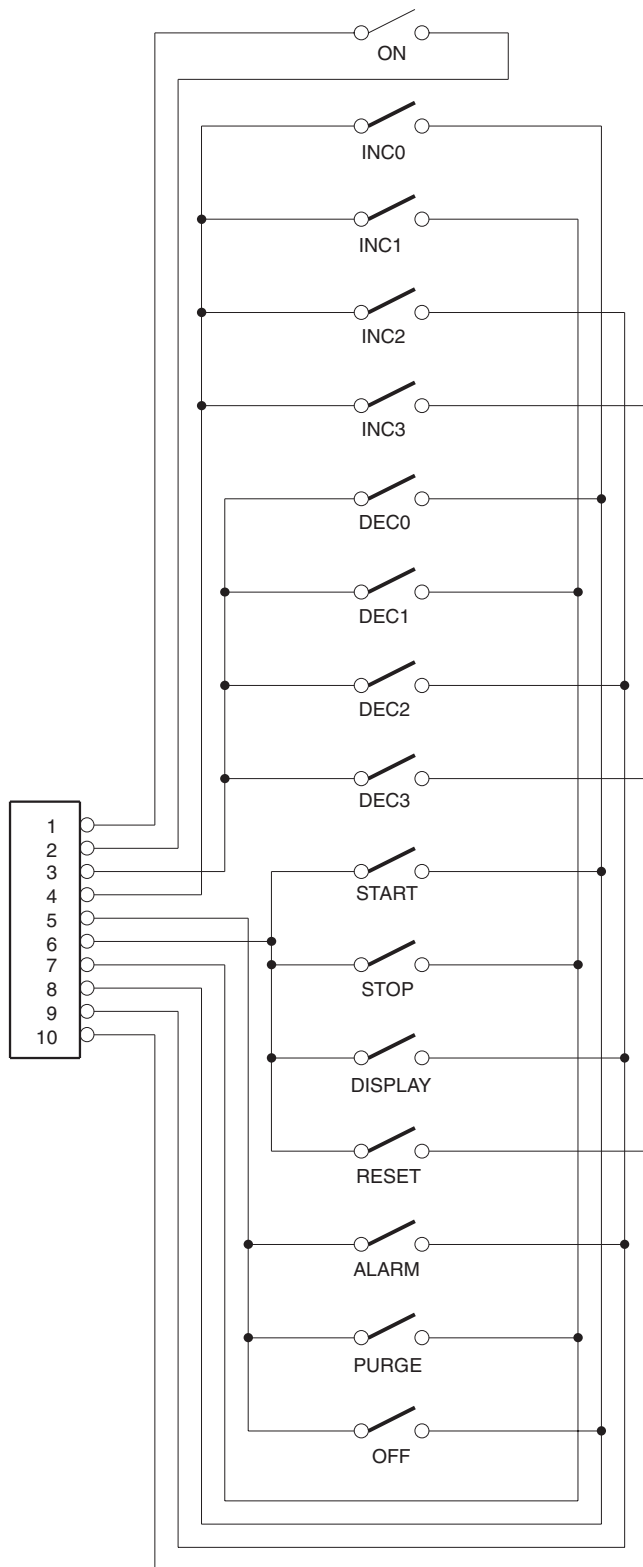
Figure 4.9 Syringe size sensors circuit



GM0095-A

Figure 4.10 Opto sensors circuit diagram

Membrane switch panel



GM0211-A

Figure 4.11 Membrane switch panel circuit

# **CHAPTER 5**

## **FAULT CODES, MAINTENANCE and REPAIR PROCEDURES**

**Graseby 3100**  
Syringe Pump

## CHAPTER 5

### FAULT CODES, MAINTENANCE and REPAIR PROCEDURES

#### Fault codes

Comprehensive fault codes have been designed into the 3100 so that should a fault occur it can easily be identified. The fault code numbers that are allocated are used to indicate the type of fault that has occurred.

Both the Main processor (IC4) and the Slave processor (IC7) in the pump are capable of recognising faults and generating fault code numbers. The Main processor is able to generate codes in the range 0 to 99 and the Slave processor in the range 100 to 199. The fault codes are not expected to change for future software versions.

The normal operational ALARMS and WARNINGS are fully detailed in the 3100 Instruction Manual.

#### Fault codes, 0 to 92

Table 5.1 Main processor fault codes

Code	Fault description
07	Ram failure (power-on self test).
10	Leadscrew turning too fast (i.e. pulses from sensor via slotted disc are more than 10% faster than expected).
11	XIRQ interrupt line asserted by Slave processor.
22	Unexpected interrupt asserted.
30	Modula programme returned to start up code.
34	Difference detected between a variable and its duplicate.
35	Variable out of its allowed range.
45	Illegal opcode detected.
46	Internal COP monitor timeout interrupt.
47	Internal clock monitor: reported error interrupt.
54	Motor interrupt operation, without foreground operation.
55	Insufficient processing time detected by task scheduler.
56	Processor CONFIG register not programmed correctly (COP not enabled and EEPROM not sited correctly).
57	Motor pulse period re-calculations disagree with original calculation.
58	Speed sensor period re-calculation disagrees with original calculation.
61	A node check baton has the wrong value.
70	CPU test failure (power <b>ON</b> self test).
85	Power supply overvoltage during power <b>ON</b> self test.
86	Motor has wrong current during power <b>ON</b> tests.
87	ROM CRC failure during power <b>ON</b> self test.
90	EEPROM index corrupt or, EEPROM expired.
91	A short circuit has occurred on the membrane switch panel during power <b>ON</b> self test.
92	EEPROM data corrupt.



Fault codes, 100 to  
112

Table 5.2 Slave processor fault codes

Code	Fault description
100	Internal COP monitor timeout interrupt .
101	Internal clock monitor interrupt.
102	Main processor resetting software watchdog too frequently.
103	Processor not resetting software watchdog frequently enough.
109	Timeout while waiting for initialisation from Main processor.
110	SPI write collision detected by hardware.
111	Unexpected interrupt asserted.
112	Program checksum failed (power <b>ON</b> self test).

**Maintenance****CAUTION**

The 3100 must **NOT** be immersed in any liquids.

**Immediately wipe off any liquid that may be accidentally spilt on the pump.**

**Cleaning**

The outer surfaces of the pump can be cleaned by wiping them over with a damp cloth (soapy if necessary).

**Fuse renewal****WARNINGS**

**The following procedures must only be carried out by a suitably qualified technician.**

**The pump must be disconnected from the AC power supply before the case is opened.**

**If the AC voltage settings are altered, the label on the underside of the pump and also the AC fuse rating must be changed to indicate and cater for the new AC voltage.**

**The safety and reliability of the pump may be compromised by the use of parts other than those specified in this Manual.**

The pump contains three safety fuses which are located on the Regulator board (see *Figure 7.8* for their location). Details of these fuses are as follows:

- FS1 is a fuse located in the unregulated DC line and has a 500 mA rating.
- FS2 is an AC supply time delay fuse having the following alternative rating:
  - T 50 mA for a 220-240 V AC supply.
  - T 100 mA for a 100-120 V AC supply.
- FS3 is a fuse located in the battery supply line and has a 1 ampere rating.

In order to renew a blown fuse the 3100 casing must be disassembled as detailed on page 2-2, this action will allow access to all three fuses. A blown fuse must only be replaced by a new fuse of the correct rating. Reassemble the casing as detailed on page 2-2.

**Repair procedures**

In several of the repair procedures that follow, information has been given on how to remove and renew the whole of the particular assembly.

If a single component within an associated assembly is faulty and can be individually repaired, then reference to the appropriate illustrated parts exploded view may enable the single faulty component to be renewed.

If a leadscrew assembly or a half nut is repaired, then the following checks and if necessary the associated adjustments must be carried out:

- thrust check (see page 2-5).
- plunger clamp checks (see page 6-3).

Whenever the case is taken apart the Syringe Size Sensors tests detailed on page 6-1 must be carried out.

**Main board renewal**

1. Open the 3100 casing (see page 2-2).
2. Remove and retain the six pan head self tapping screws that fix the Main board to the 3100 front casing.
3. Displace and carefully turn the faulty board over. Disconnect the six connectors from the underside of the board; from the left, plug PL7, 4, 2, 1, 6 and 3 (*Figure 7.7*).
4. Remove the faulty Main board.
5. Fit a new board by reversing steps (2) and (3) above, and close the casing (see page 2-2).

**Regulator board renewal**

1. Open the casing (see page 2-2).
2. Make a note of how the eight spade connectors are mounted on the Regulator board and then slide and lift the connectors off.
3. Prise open the two nylon retaining clips and release the four wires.
4. Remove and retain the two screws that hold the transformer in place. The left hand screw is 25 mm long and the right hand screw is 8 mm long. Lift out the transformer.
5. Disconnect the two bottom left hand connectors (PL11 and PL12; *Figure 7.8*) from the Regulator board by prising the side retaining clip from each connector and then pulling the connector out.
6. Remove and retain the two screws that hold the Regulator board in place and then remove the faulty board.
7. Fit a new board by reversing steps (2) to (6) detailed above, and then close the casing (see page 2-2).

**Opto sensors board renewal**

1. Open the casing (see page 2-2).
2. Remove and retain the six pan head self tapping screws that are used to fix the Main board to the front casing and turn the board over.
3. Carefully lift up the retaining clip on PL7 (Main board; *Figure 7.7*) and disconnect PL7.
4. Remove and retain the screw and washer that fixes the ribbon cable clip of PL7 to the chassis.
5. Remove and retain the two fixing screws and washers from the front of the Opto board.
6. Ease out the plastic flag from the sensors assembly and remove the faulty Opto sensors board.
7. Fit a new Opto board by reversing steps (2) to (6) detailed above, and then close the casing (see page 2-2).

**AC transformer renewal**

1. Open the casing (see page 2-2).
2. Make a note of how the eight transformer spade tags are connected to the Regulator board and then slide and lift the tags off.
3. Prise open the two nylon retaining clips and release the four transformer wires.
4. Remove and retain the two screws and the spacers that hold the transformer in place. The left hand screw is 25 mm long and the right hand screw is 8 mm long.
5. Lift out the faulty transformer.
6. Fit a new transformer by reversing the steps (2) to (4) detailed above and then close the casing (see page 2-2).

**Plunger clamp and half nut assembly renewal**

This assembly (*Figure 7.2*) is held in place by a narrow retaining spring, two circular guide tubes, and two clamp brackets that retain the square lay shaft (*Figures 7.1 and 7.2*)

1. Open the casing (see page 2-2).
2. Unhook the top of the retaining spring (2 mm dia. by 2.5 cm long) from the syringe size sensor lever arm.
3. Remove and retain the three screws from the two clamp brackets that hold the lay shaft in place. Remove and retain the two brackets.
4. Lift up the square shaft and toggle mechanism; and carefully ease out the flag from its housing on the left.
5. Lift the two guide tubes off their respective seating then remove the entire assembly.
6. Fit the new assembly by reversing steps (2) to (5) detailed above.
7. Close the casing (see page 2-2).

**Pole clamp assembly renewal**

1. Remove and retain the two screws that are inserted into the stainless steel bracket on the base of the pump.
2. Remove the faulty assembly.
3. Fit the new assembly by reversing step (1) detailed above.

**Leadscrew assembly renewal**

The leadscrew assembly is held in the rear casing by two bearing clamp plates. It is also kept under tension by a strong adjustable spring. The keyed coupling bush that screws into the right hand end of the leadscrew has a 'left hand' thread<sup>1</sup>.

1. Open the 3100 casing (see page 2-2).
2. If necessary, turn the leadscrew in order to reveal the small grub screw situated in the occlusion nut on the right hand side of the leadscrew. Using a 1.5 mm hexagon key, loosen the grub screw.
3. Ensuring that the leadscrew does not turn, move the occlusion nut counter-clockwise (i.e. towards the left) in order to relax the spring tension.
4. Remove and retain the two pan head self tapping screws that hold the right hand bearing clamp plate in place; remove and retain the plate.
5. Lift out the leadscrew, complete with the motor and gear box. The motor and gear box are coupled at the right hand end of the leadscrew.
6. Uncouple the faulty leadscrew from the gearbox by pulling it away from the gearbox shaft.
7. Fit a new leadscrew assembly (see Note below) by reversing steps (2) to (6) detailed above. Tighten the grub screw to  $15 \pm 2$  cNm. Alternatively, renew the motor and gearbox assembly as detailed in the following section.

**Note:**

During the fitting of the new leadscrew the spring assembly may have to be compressed to the left in order to fit it into the appropriate grooves in the rear casing.

8. Ensure that the groove on the syringe size sensor collar (through which the larger telescopic tube slides) fits correctly into the concaved rear casing.
9. Assemble the casing (see page 2-2).
10. Complete the thrust checks and plunger clamp checks/adjustments (see page 2-5 and 6-3 respectively).

<sup>1</sup>If the LH thread coupling bush is removed, the torque required when refitted must not exceed 40 cNm.

**Motor and gear box assembly renewal**

There is a small plastic coupling between the leadscrew and the gearbox (*Figure 7.4*, item 2).

1. Open the casing (see page 2-2).
2. Remove the Main board (see page 5-4) and disconnect the motor cable from the Main board (PL2).
3. Remove the leadscrew assembly (together with the motor and gearbox assembly) see page 5-7, steps (2) to (5).
4. Pull the faulty motor and gearbox away from the leadscrew.
5. Fit a new motor and gearbox assembly by reversing steps (2) to (4) above, and then assemble the casing (see page 2-2).

**Occlusion clutch and disc assembly renewal**

The occlusion clutch and disc assembly is situated on the left hand side of the leadscrew assembly underneath the Opto sensors board.

1. Open the 3100 casing (see page 2-2).
2. Remove the Opto sensors board (see page 5-5).
3. Remove the leadscrew assembly (see page 5-7, steps [2] to [5]), complete with the motor and gearbox assembly.
4. Remove and retain the two screws and the bracket that holds the clutch and disc assembly in place.
5. Remove the faulty clutch and disc assembly.
6. Fit a new clutch and disc assembly by reversing steps (2) to (4) detailed above, and then assemble the casing (see page 2-2).
7. Carry out the thrust checks and plunger clamp checks/adjustments (see pages 2-5 and 6-3 respectively).

**Membrane switch panel renewal**

The Membrane switch panel has an adhesive backing that enables it to be fixed to the top of the front casing. Take care not to unduly bend the new switch panel or its flexible cable loom.

1. Open the 3100 casing(see page 2-2).
2. Displace the Main board by removing the 6 screws, and disconnect the switch panel ribbon cable connector PL3 (this is a non-locking connector) from the right hand underside of the board.
3. Starting by lifting a corner, peel the faulty switch panel away from the case; pull the loose connector out through the front casing slot, and remove the faulty switch panel.
4. Remove traces of old adhesive from the front case recess (a cloth lightly dampened with white spirit may be used).
5. From the top of the new switch panel peel back the protective paper backing as far as the top of the display window.
6. Push the connector and flexible lead of the new switch panel through the slot in the case.
7. Align the top edge and sides of the panel with the top and sides of the case recess. Gently rub the top edge of the switch panel to adhere it lightly to the case and then remove the remainder of the protective backing paper.
8. Working from the top downwards and using light pressure lay the panel into the case recess.
9. When the switch panel is positioned correctly into the case recess (i.e. no over-hanging edges), use a soft cloth to rub the panel down firmly, pushing out any air bubbles at the same time.
10. Connect PL3 to the Main board and using the six screws that were previously removed, refit the Main board to the top halve of the casing.
11. Assemble the casing (see page 2-2).



**Super nut renewal**

Early 3100 pumps (pre s/n 56905) were fitted with a half nut. From May 1999, the half nuts were replaced with a three-quarter super nut. The following procedures refer to the super nut.

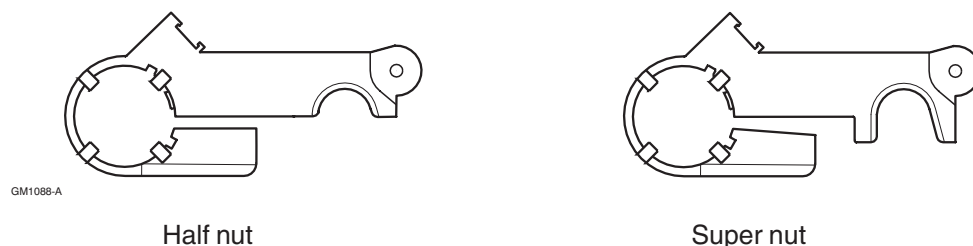


Figure 5.1 Half nut (obsolete)/Super nut

The super nut casting (*Figure 7.2*) is clamped onto the left hand end of the outer metal tube by an M4 countersunk screw. This screw is tightened into a recessed hexagonal nut. It is also attached to the toggle mechanism by a Spirol connecting pin.

1. Open the casing (see page 2-2).
2. Remove and retain the Spirol connecting pin that fixes the super nut to the toggle mechanism.
3. Unhook the top of the retaining spring (2 mm dia. by 2.5 cm long) from the syringe size sensor lever arm.
4. Lift the two guide tubes off their respective seating and remove the attached assembly complete with the faulty super nut.
5. Remove and retain the half nut countersunk clamping screw and associated nut.
6. Lever the sides of the half nut apart in order to disengage the casting pip from the locating hole in the guide tube.
7. Fit a new half nut by reversing steps (2) to (6) detailed above.
8. Close the casing (see page 2-2).
9. Carry out the thrust checks and plunger clamp checks/adjustments (see pages 2-5 and 6-3 respectively).

**Syringe size sensor board renewal**

1. Open the casing as detailed on page 2-2.
2. Unscrew the Main board (see page 5-4).
3. Disconnect the flexible cable loom connector, PL6, from the Main board.
4. Remove and retain the two screws that hold the sensor board in place.
5. Remove the faulty sensor board complete with its cable loom and connector.
6. Fit the new sensor board by reversing steps (2) to (5) detailed above.
7. Close the casing as (see page 2-2).

## Plunger clamp repair

The plunger clamp cover must be removed in order to reach the internally located lock or pin moulding. The outer casing of the clamp is fixed to the right hand end of the outer tube.

1. Remove and retain the two screws that holds the plunger clamp cover onto the outer casing and remove the cover.
2. The lock and pin moulding together with the associated spring will become accessible.
3. As required, fit a new lock and/or pin and assemble the clamp as detailed in step (1) above.

## Batteries. Checks and replacement

### WARNING

**The internal pump batteries must be disposed of in accordance with the manufacturers instructions. Lead acid batteries must *not* be placed in the normal waste stream.**

We recommend that the condition of the three internal batteries is checked at least annually. The batteries will normally last several years, but if they should fail to charge then all three batteries must be replaced at the same time. The batteries are held in place in the front casing by three-pronged flexible plastic mouldings.

### Checks

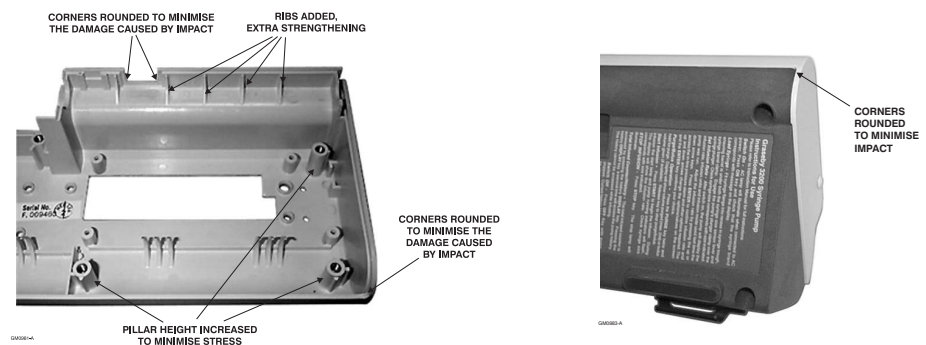
Connect the pump to AC power; ensure that the pump is switched off and the yellow AC light is illuminated, this will allow maximum DC charge supply from the regulator board. Fully charge the batteries for at least 14 hours. Remove the AC power and run the pump at 100 ml/hr. If the **LOW BATTERY** alarm appears on the pump's display before 3 hours has elapsed then all three batteries should be replaced, as detailed below:

### Replacement

1. Open the case (see page 2-2).
2. Noting their orientation, prise out the three faulty batteries. Also noting the connections remove all six spade tags.
3. Reconnect three new fully charged 2 V, 2.5 AH, lead acid D Cell batteries by reversing the steps detailed in (2) above, ensuring that the two rubber packing spacers that are attached to the pillars are still in place.
4. Close the casing (see page 2-2).

## Front and/or rear case repair

In March 1999, a new type of strengthened and modified front and rear case moulding was introduced for the 3000 range of syringe pumps (see *Figure 5.2*).



*Figure 5.2 Strengthened rear case moulding*

If an old style front or rear case becomes damaged and requires replacing then the appropriate repair kit is available from Smiths Medical. There are two kits (front or rear case) which each contain all the necessary instructions and parts to carry out a repair.

The contents of the repair kits are shown in *Tables 5.3, 5.4 and 5.5* (see page 5-12 and 5-13). The items marked with an asterisk (\*) may be obtained individually.

**Table 5.3 Front case spares kit**

Description	Part No.	Remarks
Front case spares kit (English)	0131-0274	
Label, front panel (English)	0131-0007	
Front case spares kit (other)	0131-0177	
Label, front panel (Other)	-	See <i>Figure 7.1</i>
Case front	0131-0150	
Syringe clamp assembly*	0131-0149	
Button, moulded*	0131-0216	2 off
Instruction leaflet	0131-0156	
Size sensor flag spares kit*	0131-0214	See <i>Table 5.3</i>
Foam spacer type 3*	0131-0218	2 off
Case templates*	0131-0235	2 off
Radius gauge, * stainless steel	0131-0234	
Case screws, M4x12, pozi pan	5001-0345	6 off

\*These items may be obtained individually.

**Note:**

The Front panel membrane is Country dependent and is supplied, separately (see *Figure 7.1, item 3*).

The English front panel membrane is supplied with the front case spare kit (part number 0131-0274).

**Table 5.4 Size Sensor Flag spares kit**

Description	Part No.	Remarks
Size sensor flag spares kit*	0131-0214	
Size Sensor Flag moulding	0131-0135	
Size sensor shim (0.6 mm thick)*	0130-0107	
Size sensor shim (1.0 mm thick)*	0130-0108	
Size sensor shim (1.2 mm thick)*	0130-0190	
Size sensor shim (1.4 mm thick)*	0130-0185	
Screws, No. 4 x 5/8 ins. Self tap	5017-3410	2 off
Grub screw, M4 x 6, nylon*	0131-0144	
Tamper proof protective cap*	0131-0136	
Instruction leaflet	0131-0217	

\*These items may be obtained individually.

**Table 5.5 Rear case spares kit**

Description	Part No.	Remarks
Rear case spares kit*	0131-0185	
Case, rear, modified	0131-0276	
Foam spacer type 1*	0131-0204	
Foam spacer type 2*	0131-0205	3 off
Rubber foot*	0126-0028	2 off
Catch,button	0128-0117	
Strip, retaining	0128-0118	
Case screws, M4x12, pozi pan	5001-0345	6 off
Screw, M3x10, pozi pan csk	5000-6317	
Screw, M3x6, slot pan	5000-6112	
Instruction leaflet	0131-0156	

\* These items may be obtained individually

**Note:**

The Case rear label is Country dependent and can also be supplied, e.g. 0131-0137, English, 240 V

# **CHAPTER 6**

## **FUNCTIONAL TESTS**

**Graseby 3100**  
Syringe Pump

## CHAPTER 6

### FUNCTIONAL TESTS

The functional tests have been designed to verify that the 3100 is safe to use. Complete the following tests before putting the pump into service for the first time, and then as required.

**Table 6.1 Functional testing of 3100**

Step	Test	Method	Correct result
1	Mechanical inspection	Before applying AC power, check that the case and exposed mechanical parts are free from any damage.	No visible damage.
2	Electrical safety test	For routine electrical safety testing, Smiths Medical recommends that units are tested in accordance with the UK Medicine and Healthcare products Regulatory Authority (MHRA) guideline document MDA DB9801, supplement 1 (December 1999) for Class II, Type CF equipment as a minimum.	
3	Initial power <b>ON</b>	Connect the AC supply.  Press the <b>ON</b> button.	The <b>AC</b> LED lights.  All LEDs are briefly illuminated, the alarm briefly sounds and the <b>STOP</b> and <b>AC</b> LED's will remain on. The last set up mode infusion rate will be displayed. If a syringe is fitted the associated syringe size LED will remain on.
4	Syringe size sensors	Perform with plunger clamp 40 mm from RHS and also at extreme LHS. Insert the following test rods (consecutively) in the syringe cradle:  20.50 mm diameter rod.  21 and 22.9 mm diameter rod.  23.70 and 26.2 mm diameter rod.  28.5 and 33.1 mm diameter rod.	Invalid syringe condition.  <b>20ml</b> LED illuminated.  <b>30ml</b> LED illuminated.  <b>50/60ml</b> LED illuminated.

**Note:**

Smiths Medical manufacture a set of Syringe Size gauges, *part number 0131-0202* (see Appendix, page A-5). The Smiths Medical Customer Care Department is able to take orders for these gauges and will supply the current price. This set of gauges enables test No. 4 to be carried out on all the Graseby 3000 Series of pumps.

(contd.)

Table 6.1 Functional testing of 3100 (contd.)

Step	Test	Method	Correct result
5	Operation of Membrane switch panel buttons	<p>With the pump still <b>ON</b>, press the <b>OFF</b> button.</p> <p>Press the <b>ON</b> button.</p> <p>Check that the pump can be programmed by pressing the up and down rate infusion buttons (<b>▲ ▼</b>), as described in the Instruction Manual (IM).</p> <p>Check that the two <b>totalizer</b> buttons operate correctly as detailed in the IM.</p> <p>Check that the <b>PURGE</b> button when pressed twice carries out a purge as detailed in the IM.</p> <p>Fit a syringe and move the plunger clamp to the closed (forward) position. Then press the <b>START</b> button.</p> <p>Press the <b>STOP</b> button.</p> <p>Press the <b>START</b> button, then move the plunger clamp to the open (back) position.</p> <p>Press the <b>ALARM</b> button.</p>	<p>The display goes blank, but the <b>AC</b> LED remains lit.</p> <p>As in Step 3 (initial power <b>ON</b>).</p> <p>The display alters according to the <b>▲ ▼</b> button pressed (see IM).</p> <p>The <b>display</b> button enables the volume infused since initial <b>START</b> infusion, or <b>reset</b>, to be displayed. The <b>reset</b> button resets the displayed infused volume to zero.</p> <p><b>ALARM</b> and <b>START</b> LEDs flash and the alarm beeps. The display shows total delivery up to a maximum of 2 ml of purge.</p> <p>The syringe size is briefly displayed; the pump starts the infusion with the <b>START</b> LED flashing and the running indication arrows on the display also flashing.</p> <p>The pump reverts to its set up mode.</p> <p>The <b>ALARM</b> sounds intermittently; the <b>ALARM</b> LED flashes, and <b>CLAMP OPEN</b> is displayed.</p> <p>The alarm is silenced and the pump reverts to its set up mode.</p>

(contd.)

Table 6.1 Functional testing of 3100 (contd.)

Step	Test	Method	Correct result
6	AC power failure	With syringe inserted press the <b>START</b> button to start an infusion, then switch off the AC supply externally.  Switch on the AC supply.	The alarm sounds intermittently; <b>AC MAINS FAIL</b> is displayed (also intermittently) and the pump continues running under battery power.  The <b>AC</b> LED lights.
7	Linear accuracy  <b>Note:</b> Use the linear accuracy gauge (see page 6-5)	Set the pump for a 60 ml BD syringe to deliver 99.9 ml/hour and close the plunger clamp at 60 ml position. Run <b>PURGE</b> in order to remove any backlash, then run an infusion for exactly six minutes.	Check that the plunger clamp moved a distance of $18 \pm 0.3$ mm. See also page 6-5.
8	Occlusion thrust	The occlusion thrust is set by applying an opposing force to the plunger clamp. This is achieved by using weights (see Chapter 2).	Refer to Chapter 2 for the occlusion thrust checks and adjustment procedures.
9	Plunger clamp alignment  <b>Note:</b> If this test fails, the super nut must be loosened. This allows the plunger clamp to be manipulated up or down a small distance, thus enabling the required 8.0 to 10 mm gap to be achieved.	Close the clamp at mid-position. Run an infusion of at least 99.9 ml/h. After 5 seconds check clamp position.	Front edge of clamp must be between 8 and 10 mm above surface of top cover See also page 6-5.
10	Plunger clamp open, leadscrew disengaged	Load a syringe and set an infusion rate. Open the plunger clamp. Press <b>START</b> .	The alarm ... <b>CLAMP OPEN</b> must be activated.
11(i)	Syringe <b>NEARLY EMPTY</b> and syringe <b>EMPTY</b> warnings	Using a BD 60 ml syringe, set the pump for a 199.9 ml/hour infusion, set the plunger clamp approx. 5 ml before end of travel; start an infusion and run to end of plunger travel.	Before the end of travel, check that the message... <b>NEARLY EMPTY</b> appears and at end of the plunger travel an <b>EMPTY/OCCLUSION</b> alarm occurs and the pump stops.
11(ii)	Syringe warnings, <3 mins to END, END (KVO = .5)	Set the pump for a 100 ml/hour infusion; set the plunger clamp approximately 15 ml before end of travel. Start an infusion.	At about 7 ml before the end of travel check that an intermittent alarm and the message... <b>&lt; 3 mins to END</b> appears, and at approx. 2 ml from the end, a continuous alarm sounds and the following message appears... <b>END (KVO = .5)</b>
			<b>Note:</b> When carrying out test No. 11 (ii) on a Perfusor pump, ensure that the syringe is set to a minimum of 18 ml.
12	Plunger clamp alarm tests	If the pump is fitted with the older style half nut (see page 5-10), the Plunger clamp alarm tests should be performed (see page 6-4).	



## Plunger clamp alarm checks

The following plunger clamp alarm checks are only required on pumps fitted with the old style half nut, and not the more recent super nut (see page 5-10).

The dual ramp gauge (*part number 0131-0084*) is used to check that the ...

### PLUNGER CLAMP OPEN

alarm is operating correctly when the plunger clamp is set to two alternative infusing positions, as shown below:

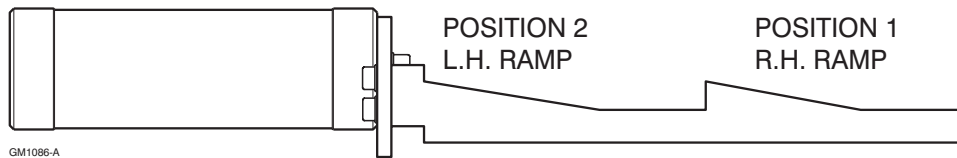


Figure 6.1 Outline of dual ramp gauge

## Ramp check procedures

1. Fit the dual ramp gauge onto the pump.
2. Close the plunger clamp at a position that is just clear of the bottom end of the right hand ramp.
3. Set the pump to infuse at a rate of 199.99 ml/h and press the **START** button.
4. Check that during the first 30 seconds of travel (as the leadscrew is fully engaged), that the plunger clamp remains clear of the ramp.
5. Check that as the plunger clamp runs up the right hand ramp a ...

### PLUNGER CLAMP OPENED

alarm occurs within 10 minutes of pressing the **START** button.

6. Repeat the above check with the plunger clamp placed just clear of the left hand ramp.

If the pump fails the ramp gauge checks (on the earlier manufactured pumps) it is recommended that the half nut is changed for a super nut (see page 5-10). Also ensure that the three following modified items have been fitted:

1. A new style square shaped flag (*part number 0127-0019*, as shown below) in place of the old style flag.
2. A new style shaft bracket (*part number 0127-0052*, as shown below). This bracket is identified by a 'V' notch that appears on one of the prongs.
3. Two new thicker washers (*part number 5014-3020*) in place of the previously fitted thinner washers that are used for fixing the opto sensors board.

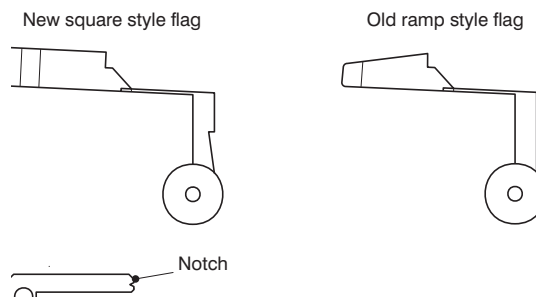


Figure 6.2 Size sensor flags

## Linear accuracy

The linear accuracy gauge (*Figure 6.3, part number 0131-0230*) when placed on the pump, is able to check that the pump's plunger clamp moves a given distance in a specified time. Initially, the pump will have been preset to given parameters, then set to run for a specified time and the distance that the plunger moves being observed on the measurement dial of the gauge.

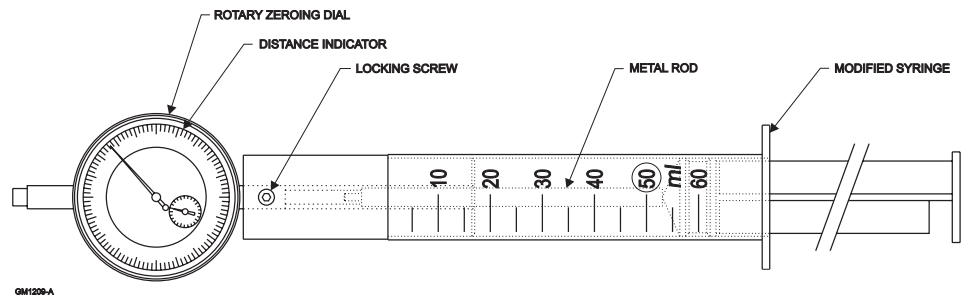


Figure 6.3 Linear accuracy gauge

### Test procedures

Test No. 7, see page 6-3

1. Place the gauge onto the pump with the syringe plunger almost fully extended.
2. Move the pump's plunger clamp to the left until the gauge plunger is a short distance away from the metal rod that activates the dial indicator.
3. Turn the pump on and check that the pump shows that the syringe brand and size is **BD 60 ml**.
4. Press the **PURGE** key until the syringe plunger just activates the gauge indicator. This action will ensure that any pump backlash is removed.
5. Rotate the outer rim of the gauge to set both dial indicators to zero.
6. Set the pump to deliver an infusion at 99.9 ml/hour.
7. Run the pump for exactly 6 minutes and check that the gauge dial records that the plunger has moved between 17.7 and 18.3 mm.

## Plunger clamp alignment

The taper gauge (*Figure 6.4*) enables the gap between the pump's plunger clamp and the case to be measured accurately. This measurement is important as it ensures that the plunger clamp will engage onto the flanges of the smaller sized syringes correctly.



GM1210-A

Figure 6.4 Taper gauge

### Test procedures

Test No. 9, see page 6-3

1. Switch the pump on and set the rate to at least 99.9 ml/hour.
2. Close the plunger clamp at approximately its mid position.
3. Run the pump for 5 seconds.
4. Using the taper gauge check that the front edge of the plunger clamp is between 8.0 mm and 10.0 mm above the surface of the case.

# **CHAPTER 7**

## **ILLUSTRATED PARTS LIST**

**Graseby 3100**  
Syringe Pump

# CHAPTER 7

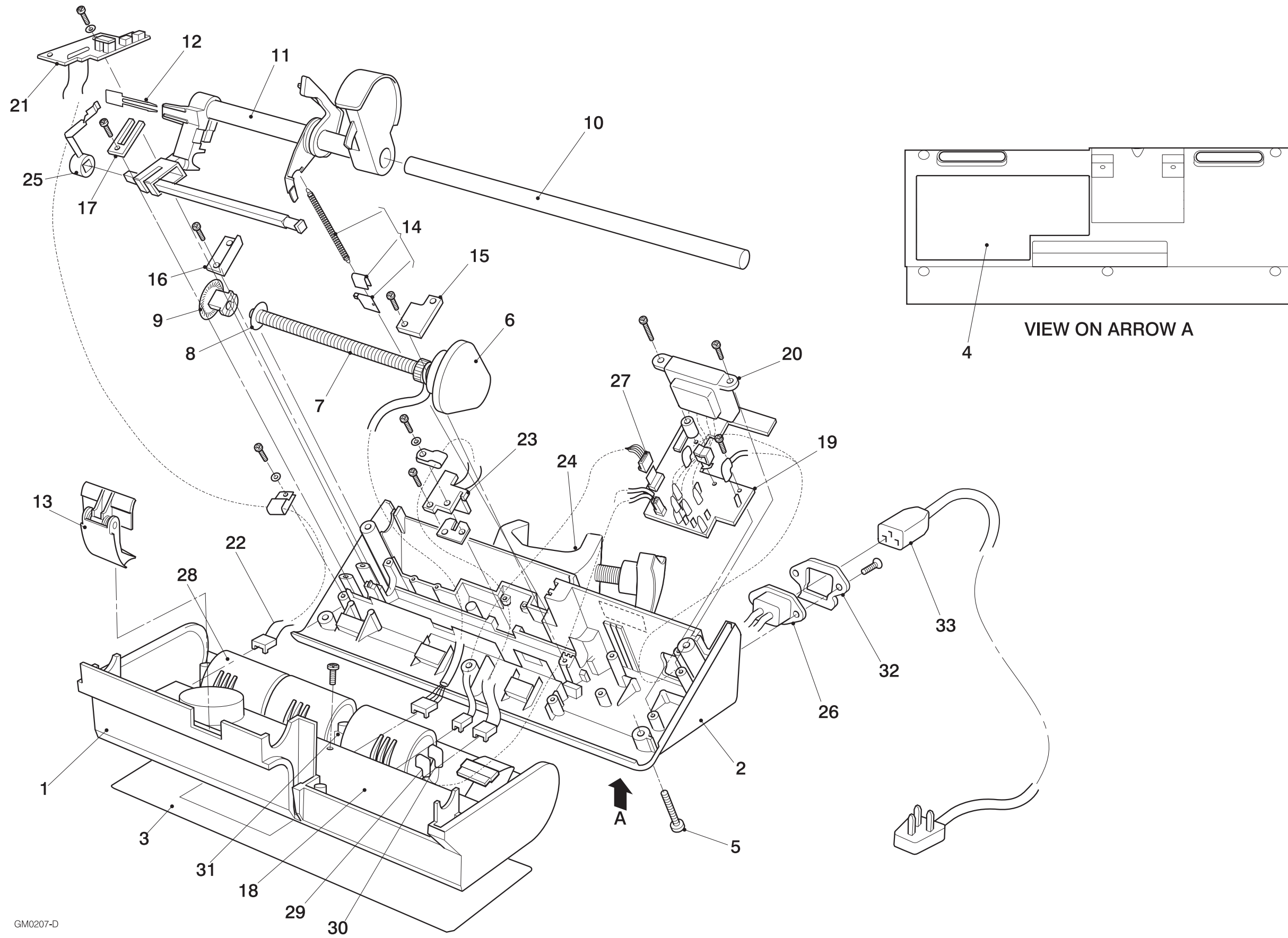
## ILLUSTRATED PARTS LISTS

Figure 7.1 General assembly

Item	Description	Part number	Remarks	
1	Front case spares kit, <i>Kit contains: Front case, Syringe barrel clamp assembly, Moulded buttons (x2), Foam spacers (x2), Size sensor flag spares kit and Instruction leaflet.</i>	0131-0177		
	Front case spares kit (English only) <i>Kit contains: Front case, Syringe barrel clamp assembly, Moulded buttons (x2), Foam spacers (x2), Size sensor flag spares kit, Front panel label (English), Instruction leaflet.</i>	0131-0274		
2	Rear case spares kit, <i>Kit contains: Rear case (modified), Foam spacers (x4), Rubber feet (x2), Screw, M3x10, Screw M3x6, Screw, case M4x12 (x6), Cable clamp, Button catch, Retaining strip, Instruction leaflet.</i>	0131-0185		
3	Membrane switch panel: - UK, Australian, Dutch	0131-0007		
	- French	0131-0024		
	- Italian	0131-0036		
	- Spanish	0131-0099		
	- German	0131-0055		
	- Portuguese	0131-0103		
4	Rear panel instruction label: <b>IMPORTANT: When ordering a CE marked rear label, please supply the serial number details of the Syringe Pump, if this information is not supplied then a Non-CE marked label will be issued. It is the responsibility of the owner to ensure that the correct labels are replaced on the pump.</b>	see table below		
	<b>3100 pump model number</b>	<b>Non CE marked serial no's below 45643</b>	<b>CE marked Made in UK serial no's from 46035 to 89999</b>	<b>CE marked Made in Malaysia serial no's from 90000</b>
	0131-0001, English 240V	0131-0137	0131-0008	0131-0283
	0131-0001, English (euro plug)	0131-0137	0131-0008	0131-0283
	0131-0701, English 110V	0131-0194	0131-0023	0131-0284
	0131-0703, French	0131-0195	0131-0025	0131-0286
	0131-0704, Italian	0131-0196	0131-0037	0131-0287
	0131-0705, Spanish	0131-0198	0131-0100	0131-0288
	0131-0707, German	0131-0197	0131-0056	0131-0285
	0131-0709, Dutch	0131-0199	0131-0097	0131-0289
	0131-0714, German (Perfusor)	0131-0197	0131-0056	0131-0285
	0131-0719, Portuguese	0131-0200	0131-0104	0131-0290
	0131-0721, English without plug	0131-0137	0131-0008	not available
	0131-0740, Australian	0131-0137	0131-0008	0131-0283

Figure 7.1 General assembly (contd.)

Item	Description	Part number	Remarks
5	Case screws	5001-0345	6 off
6	Motor and gearbox assembly	0131-0015	
7	Leadscrew assembly	see <i>Figure 7.4</i>	
8	Oil shim	0127-0084	
9	Occlusion sensing assembly	0131-0067	
10	Support tube	0127-0047	
11	Plunger clamp assemblies	-	see <i>Figure 7.2</i>
12	Near empty flag kit	0131-0122	2 types of flag supplied
13	Syringe barrel clamp assembly	0131-0149	
14	Size sensor flag retainer kit, <i>Kit contains: Anchor plate assembly and Size sensor spring.</i>	0131-0238	
15	Bearing clamp bracket	0127-0053	
16	Leadscrew bearing bracket	0127-0051	
17	Square shaft bracket	0127-0052	
18	Main board assembly	0131-0009	see <i>Figure 7.5</i>
19	Regulator board assembly	0128-0013	see <i>Figure 7.6</i>
20	Transformer: AC power	0127-0030	
21	Opto sensors board: - Current version: 6 - pin - Early version: 5 - pin	0128-0090 0127-0015	
22	Opto sensor cable: - Current version: 6 - way - Early version: 5 - way	0053-0670 0053-0655	
23	Size sensors board	0131-0032	
24	Pole clamp assembly - Non-rotating pole clamp - Rotating pole clamp	0131-0129 0131-0083	see <i>Figure 7.3a</i> see <i>Figure 7.3b</i>
25	Plunger clamp open flag	0127-0019	
26	Mains cable assembly, internal: two wire	0053-0646	
27	Power cable assembly kit, <i>Kit contains: Power cable assembly and Header</i>	0131-0242	
28	Battery - Cyclon ( <i>was P/N 3420-2120</i> )	0151-0650	3 required
29	Cable assembly battery A	0053-0647	
30	Cable assembly battery B	0053-0648	
31	Cable assembly battery C	0053-0649	
32	Cable clamp	0127-0043	



GM0207-D

Figure 7.1 General assembly



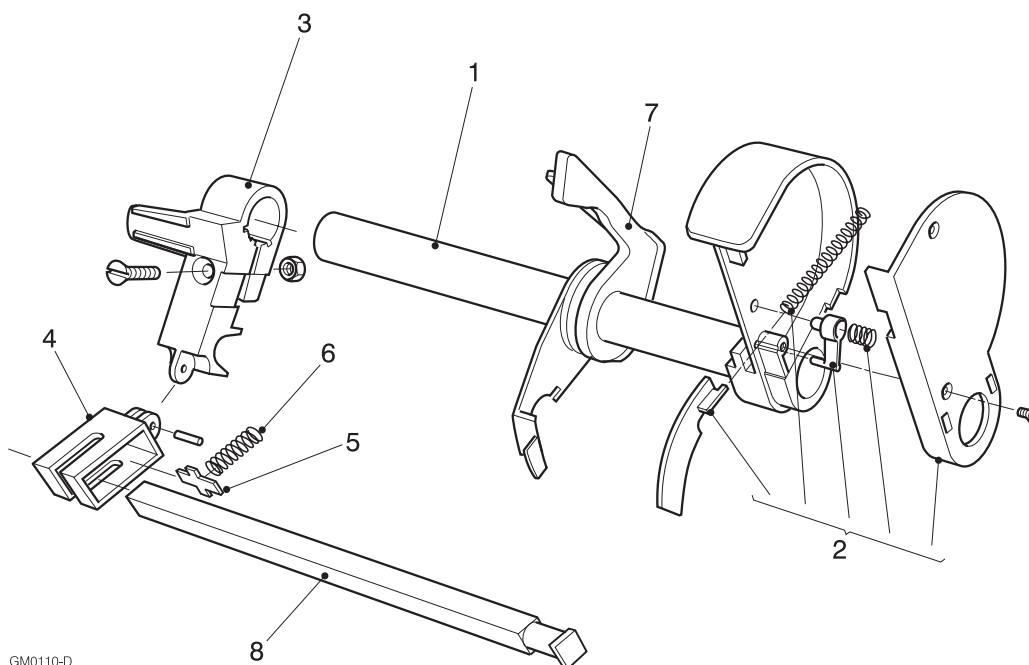
## General assembly of the 3100 (continued)

Item	Description	Part number	Remarks
33	Cordset - AC power:		
	- UK	3700-0046	UK plug
	- 110 V (USA)	3700-0230	
	- French, Spanish, German, Portuguese	3700-0035	
	- Italian, UK - without plug	3700-0025	
	- Dutch	3700-0044	
	- Australian	3700-0056	
34	Instruction Manual:		Not illustrated
	- English	0131-0018	
	- French	0131-0050	
	- Italian	0131-0047	
	- Spanish	0131-0102	
	- German	0131-0059	
	- Dutch	0131-0098	
	- Portuguese	0131-0106	
35	Technical Service Manual	00SM-0131	Not illustrated
36	5/10 ml adaptor plate	0132-0076	Germany only
37	Braun Perfusor 50 ml conversion kit	0131-0048	Not illustrated
	<i>Kit contains: Perfusor spacer tube, nearly empty flag for Perfusor, Plunger clamp plate, 'P' label.</i>		
38	Size sensor gauge set,	0131-0202	Not illustrated
	<i>Kit contains: 18 size sensor gauges and Instruction leaflet for calibration</i>		
39	Linear accuracy gauge	0131-0230	Figure 5.1
40	Taper gauge	0131-0227	Figure 5.2
41	Dual ramp gauge	0131-0084	Not illustrated
42	Security cover kit,	0131-0151	Not illustrated
	<i>Kit contains: Pole clamp assembly, Syringe cover, Cover pin bearings (x2), Cover pins (x2), Compression rings (x2), Circlips (x2), Torx screws (x2), Retaining strip, Button catch, Drilling template, Loctite 638(3ml), Screw M3x6 pan slotted, Screw M3x10 csk. pozi and Modification instructions.</i>		



Figure 7.2 Plunger clamp assemblies

Item	Description	Part number	Remarks
1	Plunger clamp and tube	0127-0044	
2	Plunger clamp cover and internal kit, <i>Kit contains: Plunger clamp cover, Plunger clamp lock, Plunger clamp pin, Plunger clamp conical spring and Plunger clamp finger spring.</i>	0131-0239	
3	Half nut casting	0131-0042	See Figure 7.4
4	Toggle moulding	0127-0026	
5	Toggle glide moulding	0127-0027	
6	Toggle spring	5752-0010	
7	Size sensor flag spares kit, comprising: <i>Kit contains: Size sensor flag moulding, Protective cap, Grub screw M4 x 6, Size sensor shim, Size sensor moulding and Instruction leaflet.</i>	0131-0214	
8	Square shaft	0127-0048	

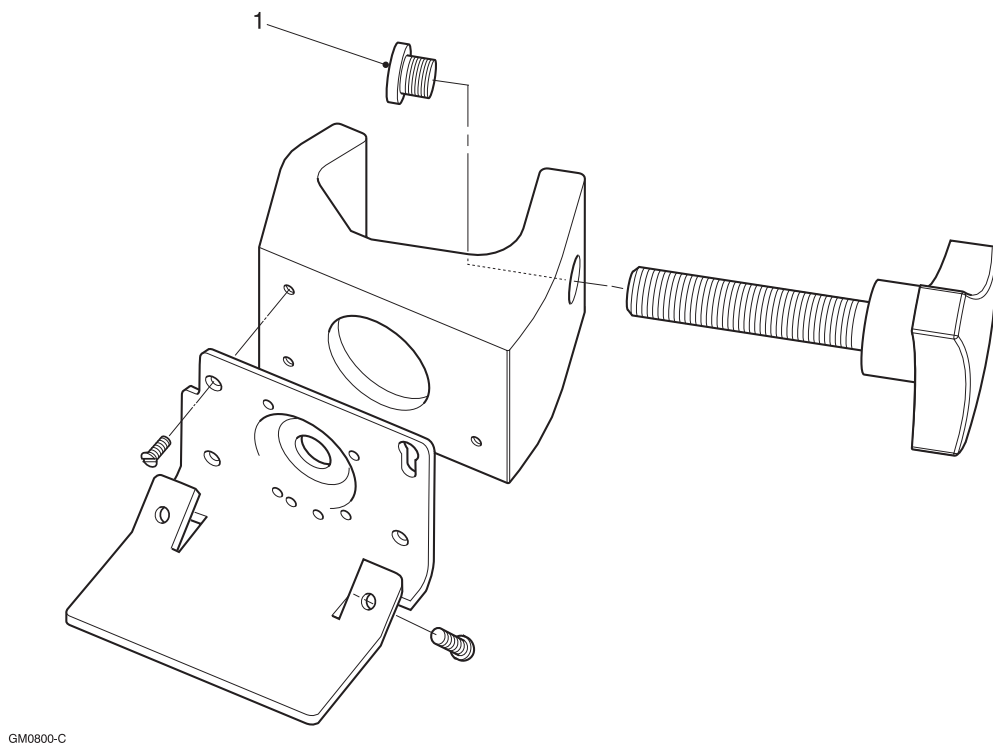


GM0110-D

Figure 7.2 Plunger clamp assemblies

Figure. 7.3a Pole clamp assembly: Non-rotating

Item	Description	Part number	Remarks
1	Pole clamp assembly (new version) Pole clamp cap-knob	0131-0129 788098-2890-4	



GM0800-C

Figure 7.3a Pole clamp assembly

Fig. 7.3b Rotating pole clamp assembly

Item	Description	Part number	Remarks
	Rotating pole clamp assembly	0131-0083	
1	Securing plate	0131-0074	
2	Locating ring	0127-0064	
3	Handle	0127-0060	
4	Pole clamp body	0131-0061	
5	Crescent circlip	5030-5710	
6	External circlip, type 7100-010	5030-4010	
7	Spirol pin 3 x 26	5028-3408	
8	Clamp pad kit, Kit contains: Clamp bolt, Clamp pad, Spacer, End cap, Screw M3 x 12, Instruction sheet.	0131-0052	

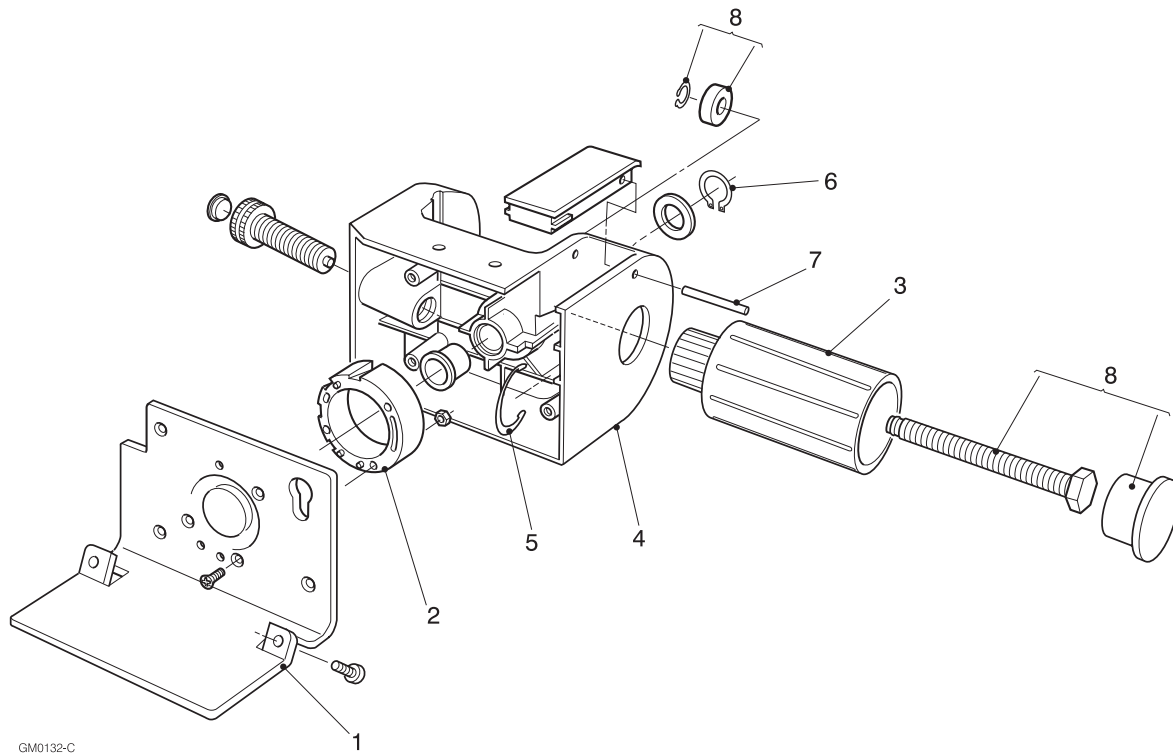
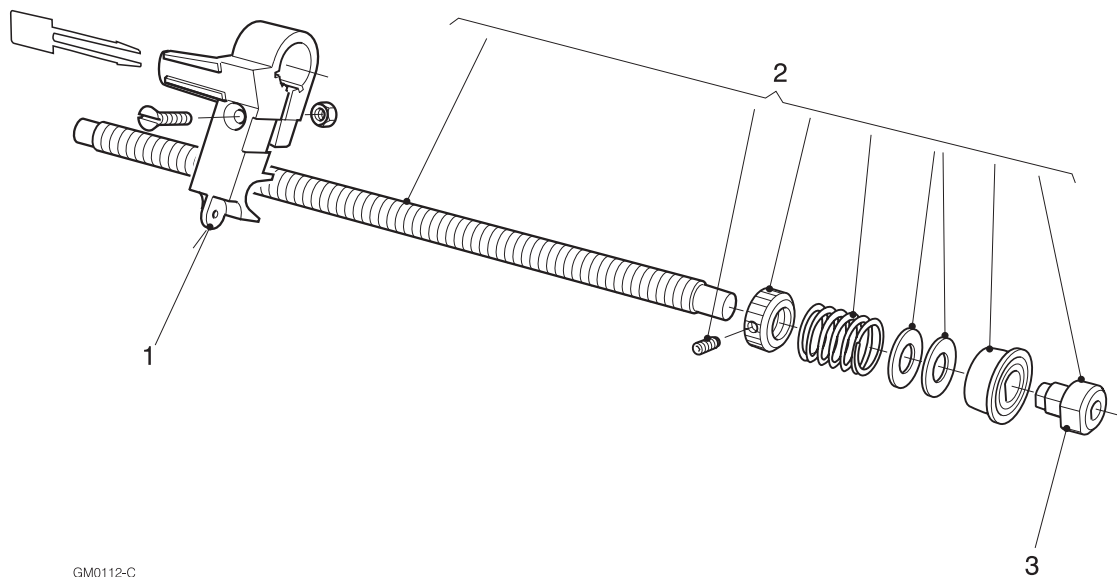


Figure 7.3b Rotating pole clamp assembly

Figure 7.4 Leadscrew assembly

Item	Description	Part number	Remarks
	Leadscrew and half nut kit <i>Kit contains the following items: Leadscrew assembly, Half nut casting, Near empty flag, Screw, Nut and Instruction sheet.</i>	0131-0236	
1	Half nut casting	0131-0042	
2	Leadscrew assembly	0131-0119	
3	Leadscrew coupling	0127-0074	

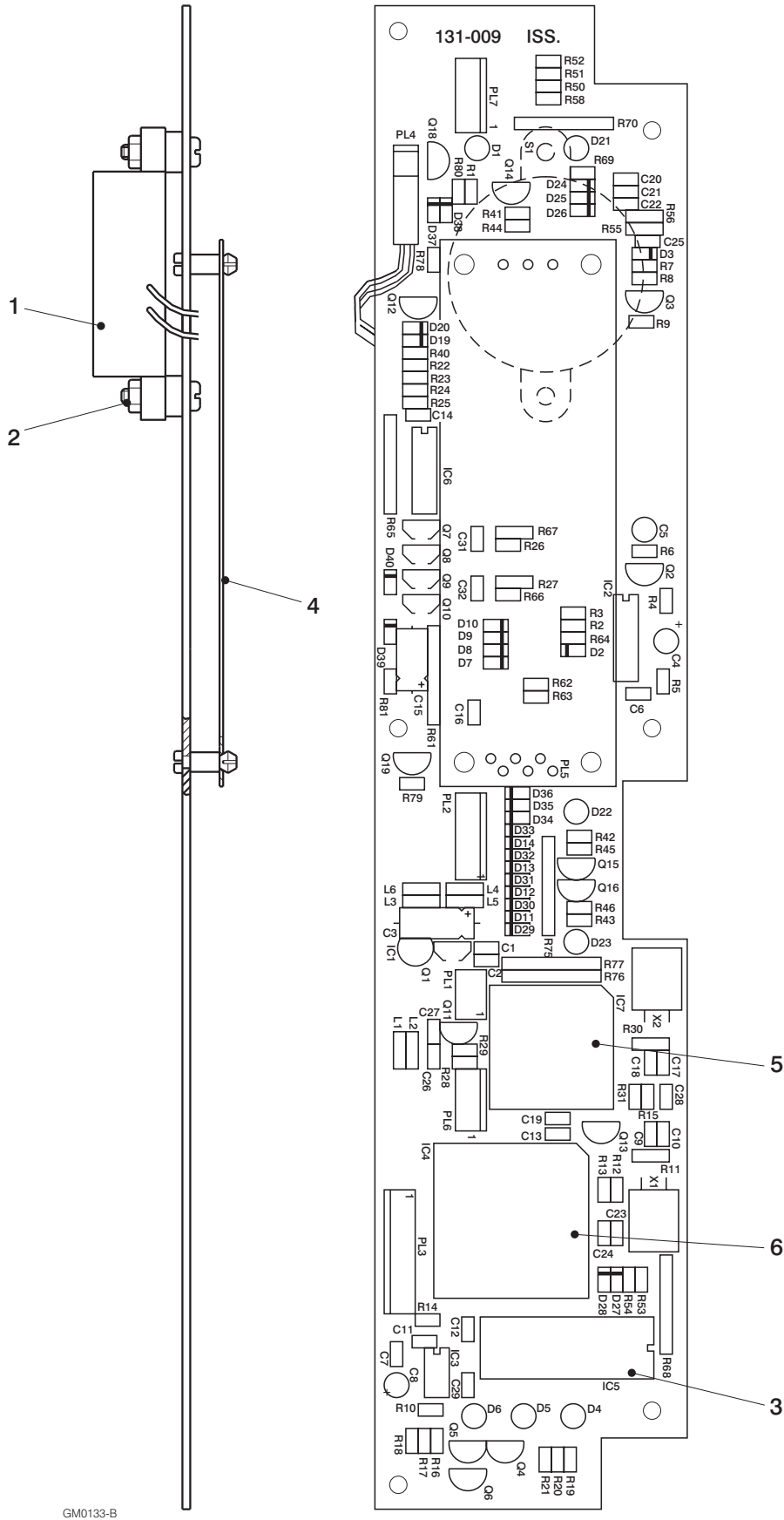


GM0112-C

Figure 7.4 Leadscrew assembly

Figure 7.5 Main board assembly

Item	Description	Part number	Remarks
1	Main board assembly	0131-0009	
	Sounder PKB5-3BO	3430-1205	
2	Sounder restraint kit, comprising: Nut M3 (x2), screw M3x16 (x2) and Pillar (x2).	0131-0240	
3	IC5, Programmed EPROM	0131-0030	
4	Display module (LCD)	0131-0011	
5	IC7, Slave processor	0131-0016	
6	IC4, MC68HC11F1FN (initialised)	0131-0072	



GM0133-B

Figure 7.5 Main board assembly diagram

Figure 7.6 Regulator board assembly

Item	Description	Part number	Remarks
	Regulator board assembly	0128-0013	
1	Fuse cover	5346-2010	
2	FS1, Fuse 500 mA 5 x 20 mm	3410-3002	UL - Bussmann GMA
3	FS2, - Fuse 50 mA 5 x 20 mm - 240 V - Fuse 50 mA 5 x 20 mm - 110V	3410-1305	
4	FS3, Fuse 1 A 5 x 20 mm	3410-3703	UL - Bussmann GMA

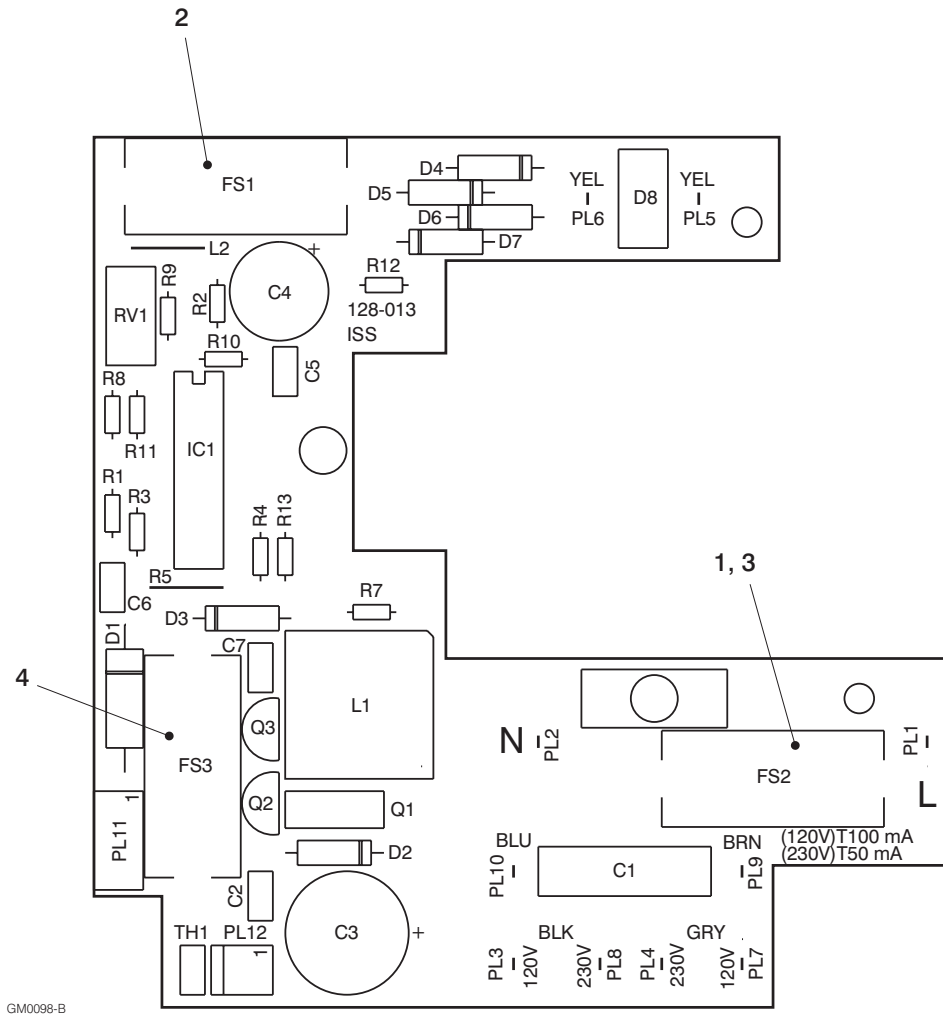


Figure 7.6 Regulator board assembly

# **CHAPTER 8**

## **BRAUN PERFUSOR CONVERSION**

**Graseby 3100**  
Syringe Pump



## CHAPTER 8

### BRAUN PERFUSOR CONVERSION

#### Syringe conversion procedures

**Introduction**

The 3100 can easily be converted, if required, in order to use the Braun Perfusor 50 ml syringe. The Perfusor conversion kit, *part number is 0131-0048*. The conversion procedures are detailed below and shown in *Figure 8.1*.

**Nearly empty flag**

Open the pump case (see page 2-3) and remove the standard flag from the top of the half nut (retain the standard flag for possible future use). Fit the elongated Perfusor 50 ml nearly empty flag by inserting the flag into the grooves on the half nut (see *Figure 8.1*). Ensure that the flag is fitted so that the small amount of flag bias is in the direction of the arrow, as shown in *Figure 8.1*.

**Note:**

If not already biased, bend/bias the end of the flag in the direction of the arrow shown in *Figure 8.1* a distance of approximately 2 mm, this will ensure that the flag (when it moves to the left) does not touch the left hand post of the rear case.

**Spacer tube fitment**

Carefully lift up the left hand end of the inner metal tube and fit the nylon spacer tube over the inner tube. The spacer tube acts as an end of travel stop when the half nut assembly moves to the left.

**Plunger clamp plate**

Fit the self adhesive half-round plunger clamp plate to the left hand side of the plunger clamp. It must be fitted to the vertical face of the plunger clamp so that it covers both quadrant vanes (see *Figure 8.1*).

Reassemble the case as detailed on page 2-3.

**Braun Perfusor selection**

The Braun Perfusor 50 ml syringe is selected for use (on the pump) by using a special configuration command.

First select the Configuration mode (see page 2-1) and then select the syringe brand display.

Simultaneously press the following three buttons:

**ALARM, PURGE and OFF.**

The pump will then switch to the Braun Perfusor syringe mode and other syringe brands will automatically be disabled. The pump syringe display will show:

**PERFUSOR 50 ml**

and the ▲ adjust button, whilst in this mode will be ineffective.

**'P' label fitment**

Fit the self adhesive 'P' label to the front of the pump in the area just above and to the right of the product name (see *Figure 8.1*). This label acts as a visual reminder that the pump must only be used with the Braun Perfusor syringe.

## Reselecting 'various' syringe brands

To reselect the various syringe brands, complete the following mechanical and programming procedures:

### Mechanical procedures

1. Take the case apart (see page 2-3).
2. Replace the original standard nearly empty flag.
3. Remove the nylon spacer from the left hand side of the inner metal tube.
4. Remove the adhesive plunger clamp plate.
5. Reassemble the case.
6. Remove the adhesive 'P' label from the front of the pump.

### Programming procedures

1. With the pump switched on and

#### PERFUSOR 50 ml

displayed within the Configuration mode (see page 2-1), simultaneously press the following three buttons:

#### ALARM, PURGE and OFF

in order to set the Configuration mode so that the various brands of syringe may be selected.

2. Set the pump to the brand of syringe that is going to be used and then press the **STOP** button in preparation for the next infusion.

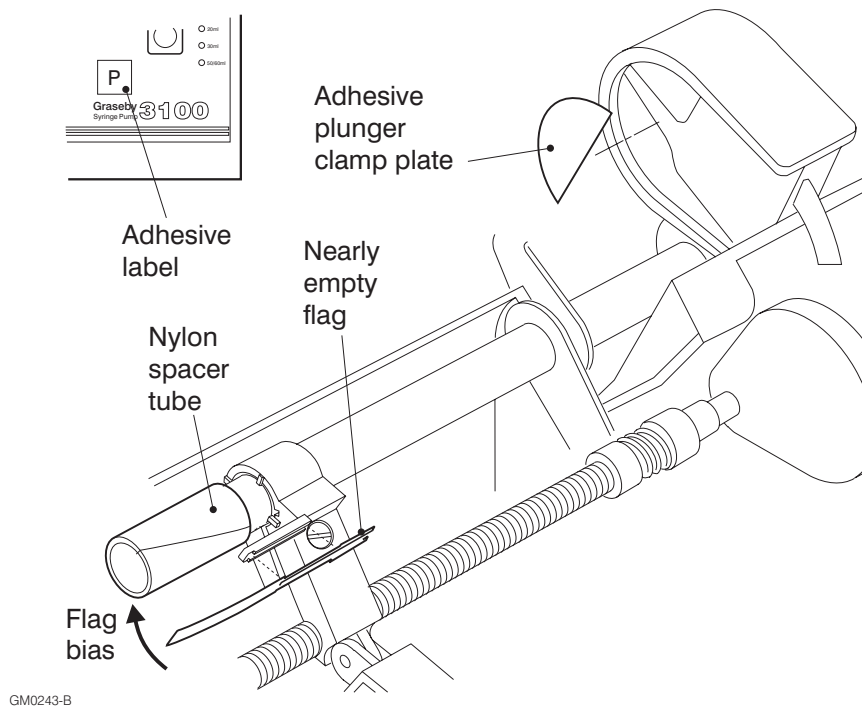


Figure 8.1 Braun Perfusor conversion: parts required

# **APPENDIX**

## **FITTING a MODIFIED SIZE SENSOR FLAG**

**Graseby 3100**  
Syringe Pump

## APPENDIX

### FITMENT of NEW MODIFIED SIZE SENSOR FLAG (SSF)

#### INTRODUCTION

In a continual and ongoing programme of improvements Smiths Medical engineers have recently introduced a modified Syringe Size Flag (SSF, see *Figure A.1*) for the 3100 pump that allows the size sensor mechanism to be accurately aligned.

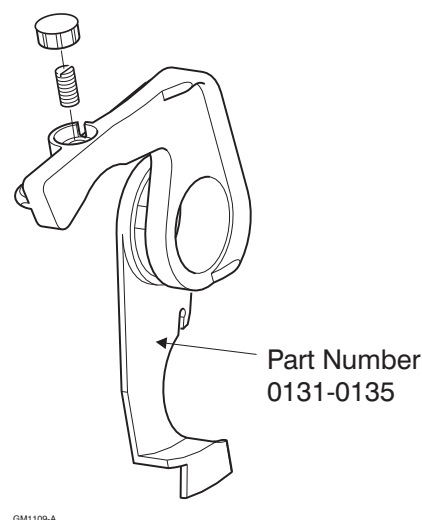
This appendix will enable a qualified Technician to carry out the fitment of the new SSF; the appropriate sized shim/s, and to carry out the final test procedures.

The SSF and shims required to modify the **3100** pump are supplied in kit form (*part number 0131-0214*).

The spares kit includes the following:

- SSF, *part number 0131-0135* (see *Figure A.1*)
- 0.6 mm thick shim, *part number 0130-0107*
- 1.0 mm thick shim, *part number 0130-0108*
- 1.2 mm thick shim, *part number 0130-0190*
- 1.4 mm thick shim, *part number 0130-0185*
- Screws, No. 4 x 5/8 inch, self-tap, 2 off, *part number 5017-3410*
- M4 x 6 nylon grub screw, *part number 0131-0144*
- Tamper proof protective cap, *part number 0131-0136*
- Instruction leaflet, *part number 0131-0217*.

The screws, washers and associated items that are removed during the disassembly of the pump are required during reassembly.



*Figure A.1 New modified Syringe Size Sensor flag*

**WARNINGS:**

When a new SSF has been fitted to a 3100 pump, the pump must be tested using the Syringe Size Sensor gauges available from Smiths Medical (*part number 0131- 0202*). Page A-3 gives details of the Final Testing procedures required.

Ensure that the AC mains supply is switched off and the pump's AC connector is removed before separating the case halves.

**CAUTION:**

During the removal and replacement of a pump's components, strict observance to Electro Static Discharge (ESD) rules must be observed at all times, i.e. an earthing strap must be worn. Failure to apply ESD protection may result in damage to the pump, resulting in its malfunction.

**OPENING THE CASE**

1. Using a scratch-free flat surface, turn the pump over to gain access to the base of the pump.
2. Undo the six screws that hold the halves of the pump cases together.
3. Place the pump upright and from the top carefully ease the casing halves apart, taking care not to put any strain on the internal connecting cable looms that form a hinge between the halves of the case.

**FITMENT OF MODIFIED SSF**

1. With the pump case open as detailed above, disconnect the long thin spiral spring from its slot in the SSF.
2. Remove the large half-nut screw, and then prise the half-nut apart and remove it from the support tube.
3. Lift the SSF and support tubes assembly up and away from the pump.
4. Remove the existing SSF by sliding it to the left, over and away from the small diameter support tube. Fit the new modified SSF.
5. Refit the half-nut screw and refit the support tube assembly to the pump.
6. Refit the spiral spring.
7. Displace the size sensor assembly by removing the two screws that hold it in position.
8. Remove any shim/s that were attached to the size sensor opto moulding. If required, clean the shim area with a suitable solvent. The shim sizes provided in the kit are **0.6, 1.0, 1.2 and 1.4 mm**. If necessary, use a combination of shims to obtain the thickness required, up to a maximum of 2.4 mm. During production a 0.6 mm shim is initially fitted to the pump.

(continued)

9. Using the two fixing screws, refit the sensor assembly to the pump.
10. Taking care not to trap any leads assemble the casing ensuring that the two case halves have snapped together and that the front and rear mating edges are equal and parallel. The six case screws should be tightened to a torque of between 70 and 75 cNm in the order shown below:

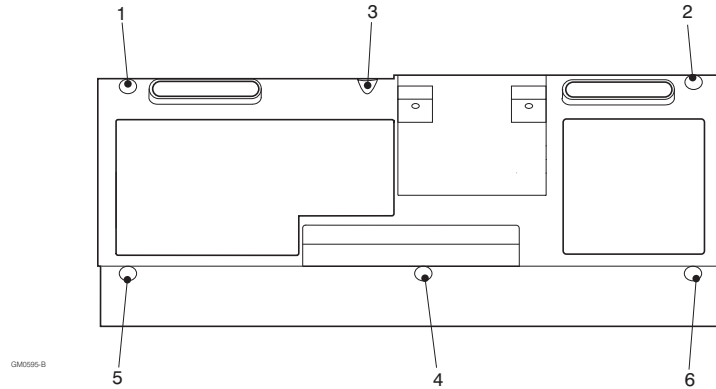


Figure A.2 Case fixing screw tightening order

## FINAL TESTING

When a new SSF has been fitted, the appropriate Functional Tests given in Chapter 6 must be completed.

Before starting the syringe size sensor tests, ensure that the pole clamp are correctly fitted and the six securing screws fully tightened (see *Figure A.2*).

The Syringe Size Sensor tests are performed with the pump's plunger clamp at the following two positions:

1. 40 mm from the right-hand side of the plunger clamp travel, and
2. at the extreme left-hand side of the plunger clamp travel.

The pump must be configured during the tests to operate with the 'BD Plastipak' syringe.

The small grub screw in the SSF must be correctly set (see *Figure A.3*) before carrying out the Syringe Size Sensor tests. The small anti-tampering cap above the grub screw must then be fixed into place using a minimal amount of Loctite 414.

### Setting the size sensor flag

1. Using the 3100 size sensor test gauges (see page A-5), fit the white 20 ml minimum sensor gauge (*part number 0131-0170*) into pump's cradle and observe whether (a) or (b) occurs:
  - a. If the pump indicates that a 20 ml gauge is fitted, complete steps (2) to (5).
  - b. If no indications are given, complete steps (6) to (8).
2. Depending upon the type of pump being set-up, if either the **20ml** LED is illuminated, or the display shows **20**, rotate the grub screw counter-clockwise until the corresponding LED/ display is extinguished or disappears.
3. Turn the grub screw slowly clockwise until the LED/ display illuminates or appears, indicating that a 20 ml syringe is fitted.
4. At position X (see *Figure A.3 Size Sensor Flag, general details*), alternately press and release the SSF several times and ensure that when the SSF returns to its rest position, it **always** displays that a 20ml syringe is present.

**Note:** It is acceptable that while the SSF is under force, the size of the syringe displayed alters. However, it must always return to the original 20ml size displayed when the force is released.

5. If the pump does toggle between different syringe sizes, turn the grub screw *very* slightly clockwise and complete step (4) again until the 20ml LED/ display is stable.

### Procedures if (b) above occurs

6. Depending upon the type of pump being set-up, if the **20ml** LED is **not** illuminated, or the display does **not** show **20**, rotate the grub screw slowly clockwise until the LED/ display illuminates or appears indicating that a 20 ml syringe is fitted.
7. At position X (see *Figure A.3 Size Sensor Flag, general details*), alternately press and release the SSF several times and ensure that when the SSF returns to its rest position, it **always** displays that a 20ml syringe is present.

**Note:** It is acceptable that while the SSF is under force, the size of the syringe displayed alters. However, it must always return to the original 20ml size displayed when the force is released.

8. If the pump does toggle between different syringe sizes, turn the grub screw *very* slightly clockwise and repeat step (7) until the 20ml LED/ display is stable.

Apply a small amount of Loctite 414 to the anti-tampering grub screw cap and fit it.

When the grub screw in the SSF has been set, the remaining procedures required to complete the size sensor testing may be completed. Press and release the SSF each time a new gauge is placed in the pump's cradle.

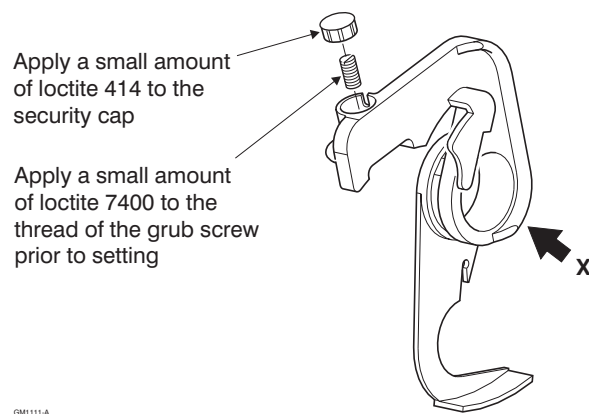


Figure A.3 Size Sensor Flag: general details

The Smiths Medical Size Sensor Gauge set (*part number 0131-0202*), contains the seven gauges that allow the Size Sensor tests on the 3100 to be carried out. The seven gauges required are listed in *Table A. 1*.

**Table A.1 3100 Syringe Size Sensor Gauges (black)**

PART No.	GAUGE DIA. (mm)	CORRECT RESULT
0131-0158	20.50	No LED lit
0131-0159	21.00 - min.	<b>20ml</b> LED lights
0131-0160	22.90 - max.	<b>20ml</b> LED lights
0131-0161	23.70 - min.	<b>30ml</b> LED lights
0131-0162	26.20 - max.	<b>30ml</b> LED lights
0131-0163	28.50 - min.	<b>50ml</b> LED lights
0131-0164	33.10 - max.	<b>50ml</b> LED lights



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The details given in this Manual are correct at the time of going to press. The company, however, reserves the right to improve the equipment shown.

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